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ORIGINAL ARTICLES.

I.—Measurement of Geological Time.

By T. Mellard Reade, C.E., F.G.S.

MANY ways of measuring geological time have been attempted by various geologists of eminence; but however diverse their methods, so far as I know, all finally hinge upon either the rates of denudation or accumulation. It is urged as an objection to this that in past ages such actions have gone on more rapidly, and therefore the calculations based upon present rates are valueless. Physicists on the other hand have sought to put a limit to the age of the earth much below what geologists generally demand. Reasoning from certain data which are necessarily more or less hypothetical, they say, that from the thermal condition of the globe at present, it cannot be more than from ten to twenty million years since it was at a temperature in which life on it would have been impossible. Geologists can hardly be blamed if they attach greater weight to their own observations and data and to reasoning that is more familiar and appears more certain and satisfactory to their minds.[1]

It is, however, quite unnecessary for me to elaborate this point, as Sir Archibald Geikie has so lately dwelt upon it in his usual lucid and telling manner.[2]

It appears to me after long study and various attempts on my own part to approximate to the length of geological time that the difficulty of getting at a satisfactory system of calculation does not arise from the unreliability of assumed rates of denudation, but from the want of a principle which will eliminate uncertain phenomena. If our modulus is the maximum thickness of all the formations we are naturally met with the objection that such a pile of strata nowhere occurs in nature. If we take as our gauge the actual thickness in any one place it may be reasonably objected that 10 feet of one set of strata may chronologically represent 1000 feet or more of another. In addition to this, how can the hiatus represented by unconformity be estimated? If, again, we start with the average thickness of the sedimentary rocks as our principal measure, it is obvious on the slightest consideration that this will give a result much below the actual time, as the particles of such sedimentary rocks have been used up over and over again, and to reach a correct result the number

[1] Since this was written Mr. Clarence King's paper ("The Age of the Earth," Amer. Journ. of Science, Jan. 1893), proves the final exception to the rule.

[2] Presidential Address to the British Association, Edinburgh, 1892.

of years which it would take to directly produce this sediment must be multiplied by the number of times the particles have been used. Let us see if we can apply these considerations in estimating a section of geological time.

For the sake of precision we will commence at the base of the Cambrian, as the underlying Archæan rocks are involved in some obscurity, though of late years a very considerable advance has been made towards their interpretation.

A Mode of Estimating the Time that has Elapsed since the Beginning of the Cambrian.

Area of Denudation entering into the Calculation.

Our point of departure being the time when the first Cambrian sedimentation began, it will be clear on a little consideration, that at the commencement, the area of denudation was necessarily the whole of the then land area of the globe, which for our calculation we will assume to have been of the same extent as now. But as time progressed and fluctuation of levels and mountain building began, these Cambrian sediments became land, and to a large extent supplied the sediment for succeeding formations. Thus the Silurian would be partly formed from the *débris* of the Cambrian, the Devonian from the Cambrian and Silurian, and so on through Carboniferous, Permian, Triassic, Jurassic, Cretaceous, Eocene, Miocene, Pliocene, and Quaternary. It is thus evident that the pre-Cambrian rocks, as they became covered with newer rocks, must have supplied sediment to the succeeding formations in gradually decreasing proportion. What mean proportion these exposures of pre-Cambrian rocks throughout the time that has elapsed from the Cambrian inclusive to the present, bore to the total land area of the globe must be largely a matter of conjecture; but to these exposures, for our purposes, must be added all igneous rocks which have come to the surface since, and have by their denudation added to the post-Cambrian sediments. For the sake of our calculation we will assume that the pre-Cambrian and igneous rocks throughout this time were as a mean one-third the area of the whole land of the globe. This then will constitute the area of denudation, or quarry, so to speak, yielding the materials for building up the post-Archæan rocks, the other two-thirds being Cambrian and succeeding rocks yielding no fresh materials to increase the bulk of post-Archæan sediments.

Actual bulk of the sediments which have accumulated since the beginning of the Cambrian.

There are several difficulties in estimating the *actual* bulk of the sedimentary rocks of the globe. These difficulties are of two kinds, as follows:

First as to thickness. It is usual in geological works to give the thickness compiled from the areas where the maximum development of the various formations occurs. Of course every geologist knows that at no one place on the earth's surface do all the formations occur together, much less in their greatest development. To put

the case clearly from the point of view of the present paper, if a series of borings were made over the great continents down to the base of the Cambrian, so as to enable us to estimate the mean thickness of all the sediments laid down since the beginning of the Cambrian, we should get the figures we require for our calculation. I am afraid that this is not likely to be done, at all events at present, either for scientific purposes, or by the wildest company promoter. We must therefore be content to adopt a minimum thickness. Considering that we have colliery sinkings all in one formation over half a mile deep, and numerous borings of half a mile, and one of a mile, through sedimentary rocks in various places, without reaching the Cambrian base, few geologists will cavil if we take the average thickness of the earth's sedimentary crust down to the Cambrian base at one mile.

Second as to area. In estimating the area of the sedimentary rocks, we are met with the difficulty that we have no actual proof of their extent under the ocean bed. There are two extreme, and some intermediate, opinions held by modern geologists. The one claim that sedimentary rocks underlie all the oceans, the other that they extend only a limited distance from the present coast-lines. It is, however, clear that the most strenuous advocate of the permanence of Ocean Basins will admit that there is sediment of one kind or another over the whole ocean bottom, though he is led from various considerations to believe that it has never formed land. Still it is sediment in part to be legitimately claimed as entering into our calculation of geological time.

For the purposes of this paper I will, however, take the bulk of post-Archæan sediment in and under the ocean as equal to that on the present land area of the globe, or, to state it in other words, the post-Archæan sediments of the whole globe are equal to the present land area two miles thick.

Rate of Erosion of Igneous Rocks.

There appears to be a concensus of opinion that one foot in 3000 years is a fair estimate of the mean rate of sub-aerial erosion over all land areas throughout all geological time. I am prepared to adopt these figures for Archæan and igneous areas also, though they are probably considerably in excess of what occurs now, the mean rate of erosion of igneous and gneissic rocks being less than the mean rate of erosion of sedimentary rocks, as is proved by their usually standing up as bosses amongst sedimentary rocks which have been stripped from them by denudation.

Calculation of the Time which has Elapsed since the Commencement of the Cambrian.

The calculation now is a very simple one. The mean area of denudation throughout post-Archæan times being taken as one-third the entire land areas of the globe, the bulk of the post-Archæan rocks being expressed by the land area of the globe two miles thick, and the rate of denudation one foot in 3000 years, the time of accumula-

tion will be $5280 \times 2 \times 3000 \times 3 = 95{,}040{,}000$. *The time that has elapsed since the commencement of the Cambrian is therefore in round figures 95 millions of years.*

Concluding Remarks.

Although the foregoing computation of post-Archæan time is on a different principle to that adopted by Sir Archibald Geikie in his Presidential Address to the British Association referred to, it is satisfactory to find that the results come out much the same. It has been objected to the latter method that deposition goes on much more rapidly than denudation, because it is assumed by those who hold this opinion that material which is denuded is spread over a much smaller area than that from which it was derived, consequently it must accumulate more rapidly. Checked by the method adopted in this paper it would appear that the earth's age geologically speaking must be, as inferred in the Presidential Address, somewhere between 100 million and 600 million years.[1]

This is a large margin no doubt, but it is an important thing to know. Different men may put different values on the three factors, bulk of sediment, rate of denudation, and area of denudation; but I think a fair and impartial examination of the reasoning involved in this paper will show that the principle of the calculation is sound.

II.—On Oolitic and other Limestones with Sheared Structure from Ilfracombe.

By Frederick Chapman, F.R.M.S.

(PLATE V.)

Introduction.

In 1886 the author, during a visit to Ilfracombe, obtained some specimens of Middle-Devonian limestones which, at the time of collecting, he supposed to be formed of *Syringopora*, on account of the granulated weathered surface, and especially since the coral named had been recorded from the locality.

After revisiting the spot in 1890, and making a somewhat extensive collection therefrom, principally for the hope of finding micro-organisms, this particular rock again attracted his attention by the peculiar granulate surface produced by weathering. A section of the rock was made which proved it to be a good example of a limestone formed of oolitic grains. Subsequently a series of specimens showing shearing in all stages was found, and these were capable of being traced back to their original source in the rock with oolitic structure.

It is the main purpose of this account of the limestones to point out the interesting changes due to dynamical and chemical agencies, in the form of shearing, silicification, and the growth of dolomite

[1] It must not be forgotten that to arrive at the earth's age Archæan time has to be added to my estimate of 95 million years, which very materially increases the margin of geologic time on which we are allowed to draw.

R. S. Chapman, photo. *Swain sc.*

Sheared Limestones from Ilfracombe.

and other crystals, which have taken place in the rocks of this district.

Description,—The limestones which appear to be in their least-altered condition are some encrinite-limestones from the east side of Hele Strand, and the cliffs at Hagginton Beach; and also others formed entirely of *Cyathophyllum cæspitosum* and many other species of Rugose corals, occurring in lenticular masses in the slates of Hagginton Hill. In these limestones, nevertheless, solitary quartz and dolomite crystals can be often seen, though the latter mineral makes its appearance in any abundance only in those rocks which have been subjected to pressure. In the specimens obtained from the neighbourhood of Rillage, and on to Watermouth, the dolomite occurs well crystallized although it performs a subordinate part in forming the mass of the limestone; but nearer to Combe Martin the rocks become completely dolomitized, where here and there, in a microscopic section, one meets with a stem-joint of an encrinite or other organism which points to the origin of the mass.

The oolitic limestone before mentioned occurs over Sampson's Cave, which is about 300 yards east of Rillage; but the rock was inaccessible *in situ*, though tumbled blocks of it were obtained at the mouth of the cave at low water. The same kind of rock was also found in freshly broken blocks at Watermouth Cave, about three-quarters of a mile to the east of Sampson's Cave. The oolitic rock is of a dark blue-grey colour, and the separate granules which weather out at the surface are quite black. Some of the specimens of this rock from Sampson's Cave have not, apparently, been subjected to much pressure, though all that were obtained show a greater or less tendency to cleave. The granules, under the microscope, are seen to be formed upon a nucleus of a shell-fragment or sometimes a quartz-grain; and they are perfectly spherical in the plane of cleavage (where such exists), and nearly so at right angles to it. The oolitic granules were found to be much harder than the surrounding matrix, when polishing a section of the rock on a snakestone; the granules standing out in relief. This hardness was found to be due to the almost entire replacement of the original grain by microcrystalline quartz. Fig. 1 shows the oolitic structure before the distortion of the granules; the latter are circular in outline and $\frac{1}{28}$ inch (·925 mm.) in diameter. Around the grains may be seen a transparent boundary or fringe with a ragged margin, which is an outgrowth of the pseudomorphous or secondary quartz replacing those grains. When the section of the rock is examined under a high-power (*i.e.* $\frac{1}{4}$ inch), innumerable crystals of iron pyrites can be seen, showing triangular, square, pentagonal, and hexagonal outlines, and occurring disseminated through the oolitic grains in isolated crystals, without any regard to the concentric structure of the former; and also in the matrix in patches and strings, filling up incipient rifts and cracks. The blue-grey colour of the limestone and the dark tint of the granules is due to this occurrence of the iron pyrites; and the mineral performs an interesting part in the subsequent alteration of the rock, as will presently be seen.

Fig. 1*a* is from a specimen which has been boiled in HCl before preparing the microscopic section from it, so that only the silica and iron pyrites are left. It will be seen that the spaces between the grains, and occasionally the centres of the latter are dissolved out, showing that a very small proportion of the original rock exists in this oolite.

Fig. 2. represents a section taken from a slightly cleaved limestone, and in a direction vertical to the cleavage, from Watermouth Cave. In this example we have the first definite appearance of shearing in the rock. At this stage the grains have only suffered slight flattening, without much distortion, but irregular fissures have been made in the mass, passing through both grains and matrix in sinuous, but roughly parallel, lines. This specimen is also more or less silicified.

At the next stage, shown in Fig. 3, there has been a great change in the structure of the rock-mass; it has been subjected to such pressure as to have caused the oolitic grains to be lengthened out to a remarkable degree, and to closely overlie one another. The length of the grains in this condition is nearly twice the probable original diameter, and the proportionate length and breadth as 5 to 1. A siliceous fringe is seen bordering these lengthened grains, when viewed between crossed nicols, but the silicification does not apparently affect the grains themselves, since a section, decalcified upon the slide, which had been cut from this rock, exhibited after the treatment dolomite crystals with a little silica around the precincts of the grains, but showing that the grains themselves had been dissolved out. It therefore appears evident that the silicification of the limestones has only happened in the case of those oolitic rocks which have escaped shearing, or which have only been slightly acted upon by pressure. In the lengthened-out grains of this specimen, the concentric layers of the oolitic grains can be distinctly seen, as can also the radial structure which is so characteristic of the older oolitic rocks. The dolomite crystals occur in lenticular strings, the centre of each lenticle being occupied by granular material (perhaps ankerite), whilst on the outer margin are very well-developed crystals of dolomite often showing zone-structure. Seen under a high power these dolomite crystals show inclusions of very minute particles of iron-pyrites, and this latter mineral also occurs in some abundance in the fissures formed by the shearing of the limestone.

In a hand-specimen this rock is of a dark blue-grey colour, with a distinct schistose structure; and traversing it, generally at right angles to the plane of schistosity, are numerous veins of pure white calcite, representing faults produced by the folding and crushing of the beds.

An analysis of this dolomitized limestone has been made for me through the kindness of Prof. Thorpe, F.R.S., by Mr. Ernest A. Pinchin, in the Chemical Laboratory of the Royal College of Science, and is as follows:—

ANALYSIS OF DOLOMITIZED LIMESTONE (dried at 100° C).

Calcium carbonate ($CaCO_3$)	74·88
,, sulphate ($CaSO_4$)	0·24
,, phosphate ($Ca_3PO_4)_2$	trace.
Magnesian carbonate ($MgCO_3$)	14·95
Ferrous carbonate ($FeCO_3$)	4·75
Insoluble (SiO_2)	5·06
Total	99·88

As sulphide of iron is present in the rock it would appear that in the analysis it is represented by the other iron and sulphur compounds.

The extreme condition of the sheared rocks found is shown in Fig. 4, from a specimen collected at Rillage Point. In this specimen the grains are drawn out to about ten times their present breadth. In one instance a grain was affected by the shearing force on a portion only, one side having been drawn out whilst the opposite side exhibits the almost circularly concentric layers of the grain. In this rock we see, besides the lengthened and contorted grains which give an appearance of fluxion structure to the mass, numerous well-formed crystals of dolomite disposed along the lines of cleavage, and which are stained by ferruginous material; also "eyes" of calcite, which can be traced to their origin as portions of joints and ossicles of crinoids.

Fig. 4*a* is from a more highly magnified photograph of the same kind of rock, but from a different specimen. In this we see the decomposition which has taken place in the included iron pyrites, and the subsequent hydration, giving rise to a brown staining which in most cases obscures the centres of the dolomite crystals and in rarer cases brings out their zone-structure. The rock itself is of a rusty-brown colour instead of the dark blue-grey colour of the fresher kinds.

Fig. 5 is taken from a rock collected at Rillage Point, and differs somewhat from the preceding series on account of the scarcity of the sheared granules and abundance of calcitic fragments and encrinite remains. In this rock there is no dolomite, and its absence is quite exceptional. The organic remains, it will be seen from the illustration, are conspicuously unaffected by the shearing, whilst the oolitic grains are very much attenuated.

Fig. 6. is from a section taken across the coralla of *Cyathophyllum cæspitosum* in a limestone formed of that coral. The attenuated form of these coralla is probably entirely due to the shearing action upon the rock. This specimen was obtained from Watermouth.

Conclusions and Suggestions.—Although the sheared oolitic limestones were all found in the immediate neighbourhood of Rillage Point, whilst the less altered specimens were obtained from localities to the east of that place, it is highly probable that further investigation will show that the comparatively unaltered oolite alternates with the sheared rock; that is to say, according to the evidence afforded all along this part of the coast of the excessive crumpling and crushing of the strata, it is only reasonable to suppose that the

different stages of this sheared rock recur at intervals according t their position in the plications where they have suffered greater o less pressure.

The dolomite crystals most probably owe their origin to percolatin water charged with salts of magnesia derived from the surroundin shales; and perhaps, in the case of the coral limestone, from th corals themselves, as a small quantity of magnesia is often presen in the corallum.

Besides forming the intercalated beds of sandstone, silica i abundant in the limestones and clay-slates in the form of minut quartz-grains and crystals; and these would readily dissolve an re-crystallize during and after the processes of contortion and shear ing, as is seen in the replacement and fringing of the oolitic grains

It is interesting to note the close association of the oolitic granule in these beds with masses of the old reef-forming corals, an associa tion similar to that found at the present time in tropical areas.

The patches of limestone in the shales undoubtedly owe thei lenticular form to the forces which produced the shearing; but o account of the superior hardness of the limestone the surroundin shales have suffered more in being squeezed out of position, an have been altered into talc on the surfaces of the mass.

In concluding these notes it remains for me to express my obliga tions and thanks to Professor Judd, F.R.S., for his kind and valuabl advice; to Professor Thorpe, F.R.S., for his kindness in supplyin me with the analysis of the dolomitic limestone; and to my brothe Mr. R. S. Chapman, for his skill in producing the photographs fro which the plate has been made.

EXPLANATION OF PLATE V.

FIG. 1.—Oolitic limestone of Devonian age, practically unaffected by pressure from Sampson's Cave. × 14.

FIG. 1*a*.—The same rock treated with acid to show the siliceous portion. × 14.

FIG. 2.—Oolitic limestone with incipient cleavage, from Watermouth Cave. × 14

FIG. 3.—Sheared and dolomitized oolitic limestone, from Rillage Point. × 14.

FIG. 4.—Extreme condition of sheared oolitic limestone, with "eyes" of calcite and dolomite, from Rillage Point. × 14.

FIG. 4*a*.—A portion of the same more highly magnified, to show the dolomit crystals with their centres occupied by ferruginous material. × 36.

FIG. 5.—Sheared limestone formed of encrinite remains and oolitic grains; th ossicles and stem-joints of the encrinites are almost unaffected by th shearing forces. From Rillage Point. × 14.

FIG. 6.—Sheared coral limestone, from Watermouth. × 4.

III.—THE SUBMERGENCE OF THE BRITISH ISLES DURING THE GLACIAL PERIOD.

By Prof. EDWARD HULL, LL.D., F.R.S., F.G.S.

THE question of the submergence of the British Isles during, at least one stage of the Glacial period, is deserving of careful considera tion by geologists. Until the visit of the late lamented Prof. Carvil Lewis to this country, no one, as far as I am aware, questioned th view that the British Isles have been submerged to a depth, i some places, amounting to 1300 or 1400 feet—this being the leve at which shell-beds are found in some parts of England, Wales, an

Ireland. Prof. Lewis, however, struck out a new theory to account for the existence of these high-level shelly-gravels, which has since been adopted by Mr. Kendall[1] and other geologists, according to which these shell-beds have reached their present altitude by the agency of the great ice-sheet, which is credited with the astonishing power of having carried these deposits from the bed of the Irish Sea, and then of having laid them down in their final resting-place high up amongst the mountain groups of Wicklow, Wales, and Central England. It might be objected to this view, that, in the first place, the matter deposited at the tail of an ice-sheet is moraine matter, not usually stratified shelly gravel and clay; in the second, that in the process of transportation, such deposits, borne along for miles in the body, or at the foot, of the ice-sheet, and carried up the mountain slopes, would be ground into the finest mud or powder; and it seems inconceivable that even a few minute fragments of shells, sufficiently large for identification, should have survived such a destructive process; but this objection is considered invalid, so that we must have recourse to others.

Well then, thirdly, the view advocated supposes either that the ice-sheet in the Irish Sea attained an original thickness of 1300 or 1400 feet in the vicinity of the mountains aforesaid *plus* an additional thickness for the depth of the adjoining sea-bed, or else that it rose up from the sea-bottom and ascended the flanks and valleys of the mountains owing to the *vis a tergo*, or some other force of propulsion. The thickness of the ice-sheet in the latitude of Snowdon must have been over 1500 feet according to this calculation (a very improbable view as it seems to me); or the ice must have pushed the shell-beds several hundred feet up the Welsh and Wicklow slopes; a phenomenon which, as far as I am aware, has no example at the present day. In making this statement, I do not deny the power of glacier-ice to move over low opposing ridges, as in the case of Bray Head, but in such cases the whole of the opposing ridge has been enveloped in the mass of moving ice; and the conditions are very different from those which would occur where the ice-sheet is confronted by the flanks of still higher ridges.

But without insisting too strongly upon this objection I have another to advance which is absolutely fatal to the transportation theory of Prof. Carvill Lewis and his followers. In the case of North Wales, those who are acquainted with its glacial phenomena, or who have studied the writings of the late Sir A. C. Ramsay, are aware that there is no evidence whatever of an ice-movement inwards from the Irish Sea; but that, on the contrary, the ice-movements radiated outwards from the mountain heights. Ramsay, indeed, clearly describes what he calls "the Drift," and shows that it consists of Boulder-clay, sand, and gravel filling the bottoms and sides of the valleys up to a level of about 1300—1400 feet; but that this Drift is of marine origin, formed during a period of submergence, he has no doubt whatever. When describing it as rudely stratified, and containing blocks and boulders carried by floating

[1] Glacial Geology, Old and New. GEOL. MAG. Dec. III. Vol. IX. p. 491.

icebergs, he says with reference to the question of submergence: "From circumstances presently to be mentioned, it is to me certain, that at a time when North Wales was so far submerged that only the higher mountain tops rose as islands, none of them more than about 2000 feet" above the surface, etc. (Old Glaciers of North Wales, p. 96). This is the deliberate opinion of one who, as Director of the Geological Survey, and as taking an active personal part in the work in North Wales for several years, had become familiar with every spot and section where the Glacial deposits were visible; and was investigating the phenomena of glaciation with the enthusiasm which their novelty at the time inspired. It is true that, as Ramsay himself determined, the ice-sheet of the Irish Channel was sufficiently thick to pass across Anglesea, and the low ground adjoining the Menai Straits in a S.W. direction; but there is no evidence whatever that it ascended the mountain slopes around Snowdon to a level of 1400—1500 feet above the present surface. It is in such Marine Drift deposits as those above described that the shells occur, not only at Moel-Tryfan, but in several other places, such as the valleys which descend from Carnedd Llewelyn, at elevations of about 1200—1300 feet and also in Denbighshire.

Then as regards Ireland, the evidence is quite as conclusive. The shell-beds which were discovered by Mr. John Kelly, and the Rev. Maxwell Close, at Caldbeck Castle, at 1300 feet, and in several other localities, not so elevated, amongst the Wicklow Mountains, are by no means solitary representatives of submergence. They are detached portions of the shelly gravels of Wexford which reach levels of 300—400 feet, and of the great deposits of sand and gravel which cover such large tracts of the central plain of Ireland, up to levels of several hundred feet, and in which sea-shells have been found at various elevations, as in the Dargle Valley, at spots west of the Sugarloaf Mountain, and south of Enniskerry, county Wicklow, up to heights ranging from 500 or 600 up to 1000 or 1200 feet according to Jukes (Manual of Geology, 3rd edit. p. 709). They have also been found in more inland places. But the presence or absence of shells in these deposits is of very little consequence; the beds are the same, whether shells have been found in them or not; and it is easy to conceive how shells, originally contained, may have been dissolved out of them by percolating rain-water. That the shell-gravels of the central plain of Ireland are the same deposits as those which contain shells in the higher elevations, and that they are the result of submergence is the clear opinion of the late Prof. Jukes (*Ibid.* p. 710). If they had been formed by an ice-sheet, that ice-sheet must have moved *from the sea* and spread itself over the land-surface of Central Ireland, but this is exactly the reverse of the case, as shown by the glacial striæ and the *roches-moutonnées*. These have all been observed and tabulated in detail over the whole country by Mr. Close, the Geological Surveyors, and others, and will be found laid down on my map of the General Glaciation of Ireland (Phys. Geol. of Ireland, 2nd edit. p. 211), from which it will be seen that the movement of the great ice-sheet was everywhere

from the land outward towards the present sea-coast. The direction of this movement, as determined by numerous observations is, I repeat, fatal to the transportation theory of Professor Carvill Lewis and his followers, which postulates a movement in an opposite direction. For myself I feel satisfied that the submergence view is the only one which meets the requirements of the case. I will only add a few words more in order to remove an erroneous impression to the effect that a submersion of 1300—1400 feet in the latitude of Snowdon and Wicklow involves a similar amount of depression to the north and south of that parallel. There is no such inference required. In the parallel referred to the depression (assuming the level of the ocean to have been constant) appears to have reached its maximum for the British Islands, gradually lessening northwards into Scotland, where, according to Prof. James Geikie, it was over 510 feet, marine shells being found in the Glacial series up to this level; in Norway they are found at 580 feet.[1] In an opposite direction beds of gravel, or scattered pebbles of quartz from the waste of the New Red Sandstone, are found up to a level of about 600 feet amongst the Cotteswold Hills on the borders of Oxfordshire and Gloucestershire.[2] No ice-sheet ever invaded this part of England, and the occurrence of these pebbles drifted from the north, and lying on the Jurassic table-land can be accounted for in no other way except by submergence. To the same series of Drift deposits are to be referred the "High-level gravels" of Oxfordshire, Wilts, Berks, Dorset, and the Isle of Wight—as also the "Middle Glacial Beds" of Messrs. S. V. Wood and J. L. Rome in the Eastern Counties, reaching elevations of about 200—300 feet. All the phenomena point to an inter-Glacial epoch of deep submergence, and the conversion of the British Isles into an Archipelago of small islets washed by cold water, and sometimes encumbered with ice of local origin.

IV.—The True Horizon of the Mammoth.

By Mark Stirrup, F.G.S.

In some recent articles contributed to the Geological Magazine, Sir Henry H. Howorth has sought to establish by a great array of authorities, both British and foreign, the pre-Glacial, or at least pre-Boulder Clay, age of the Mammoth.

As Sir Henry claims to have proved his case—a proposition which probably few geologists will admit—and "calls upon those who still maintain a post-Glacial or inter-Glacial existence of the Mammoth to prove their case," I will attempt, to offer some little evidence to show that the conclusion he has arrived at is scarcely warranted by the facts.

In order not to unduly trespass on the limited space, I do not intend to analyze the value of the British evidence which Sir Henry has

[1] In the Lake District the late Mr. Clifton Ward has traced stratified gravels up to a level of at least 1500 to 1600 feet.—"Geology of the Northern part of the Lake District," Mem. Geol. Survey, p. 94.

[2] Quart. Journ. Geol. Soc. vol. xi. p. 477.

adduced, as that has been already criticised by Mr. A. J. Jukes-Browne, but propose to confine myself simply to the consideration of the foreign evidence.

In doing so, I shall endeavour to follow as nearly as possible the path which Sir Henry has traced, and shall rely for rebutting evidence on some of the authorities he has himself quoted. His survey commences with Switzerland, and amongst other quotations, he cites somewhat at length the famous lignite beds at Dürnten and Utznach. The unsatisfactory character of much that has been written on these deposits he seems to feel, and certainly the record of the animal remains found in them will not strengthen the position he has taken up, for if they prove anything at all in support of his thesis, they prove far too much. The beds are acknowledged to be much disturbed in places, and yield not only the bones of the Mammoth and the Woolly Rhinoceros, together with the Pliocene beasts *E. antiquus* and *R. leptorhinus*; but animals of a later type, such as the cave-bear, the urus (*Bos primigenius*) and Elk, and also of existing species, as for instance the Red Deer, *Cervus elaphus* (see Heer's Primæval Switzerland and Prof. Rütimeyer).

If Sir Henry Howorth claims the Mammoth for a pre-Boulder Clay animal, he will scarcely be bold enough to claim all its associates in these lignite beds as of a like age.

Turning now to the authority of M. Favre, who is cited as "saying distinctly that the Glacial beds with their erratics, which are greatly developed in the neighbourhood of Geneva, are superimposed on the so-called 'alluvion ancienne,' *i.e.* the stratum in which the Pleistocene animals occur."

The phrase, "alluvion ancienne," as used by Swiss geologists, has not a fixed application, as will be seen from the following extract taken from Prof. Favre's "Recherches Géologiques dans les parties de la Savoie," vol. i. p. 32, in which he describes the Terrace Alluviums in the neighbourhood of Geneva as belonging to the prehistoric age, but which are perhaps contemporary with Man.

M. Favre goes on to say "that some authors call them 'alluvions anciennes,' and others *post-glacial* alluviums. They never contain striated stones nor erratic blocks. They are *superimposed* on Glacial beds, etc." (the italics are mine).

But further, Prof. Favre expresses himself explicitly on the point under discussion as to the true horizon of the Mammoth (*op. cit.* p. 50): "The remains of *Elephas primigenius* found in our country are valuable in that they fix in a very positive manner the age of that animal—they come from the *post-Glacial* beds."

Again, on page 52, M. Favre says, "In the interior of the Jura, bones of *E. primigenius* have been found at Tenay upon the railway line from Lyons to Geneva, and on the other side of the chain, near Poligny, remains of this animal have been gathered in the sands and gravels *above* the Glacial beds with polished and striated stones. It is still in the post-Glacial alluviums that the bones of *Elephas primigenius* have been met with near Tullins in Dauphiny. It is then evident that if the *E. primigenius* lived during the Glacial

epoch, a fact which does not appear to me yet sufficiently proved, it has equally inhabited our country during the formation of the terrace alluviums." From the above extracts it will be seen that Prof. Favre's opinions afford no support to Sir Henry Howorth's contention.

M. Falsan, another authority quoted by Sir Henry, but apparently only on the question of inter-Glacial periods, classifies, in his Synoptical Table (*vide* La Période Glaciaire) of the Pliocene and Quaternary Beds of the Environs of Lyons, *E. primigenius* as post-Glacial, and occurring in the Lehm, uniformly spread over the ancient or Glacial alluviums.

In the valley of the Rhine it is also in the superficial loamy deposits called Lehm or Loess, which certainly belong to the closing phases of the Ice-Age, that we find the most abundant remains of the Mammoth and its contemporaries; moreover, the cavern deposits of both England and the Continent afford ample evidence of the co-existence of Man and the Mammoth.

In America, Sir Henry Howorth says the evidence seems to be very contradictory. It is truly a stumbling block to the acceptance of his conclusions. The remains of the Mammoth and Mastodon are well known to occur there in the most superficial deposits. Prof. Shaler says: "Almost any swampy bit of ground in Ohio or Kentucky contains traces of these animals; and at Big Bone Lick the remains are so well preserved as to seem not much more ancient than the Buffalo bones which are found above them."

Indeed, the evidence of the true Mammoth having existed in America, long after the period of the Northern Drift, seems so conclusive, and is so well known to geologists, as to be almost beyond question.

In bringing these criticisms to a conclusion, with that of the Russian evidence, on which Sir Henry, relying on the opinion of his "old masters" has always laid great stress, I propose, instead of resorting to ancient history, to bring forward the published researches of living and recent explorers for the refutation of my friend's postulate.

For the first example I quote the stratigraphical and palæontological testimony afforded by the recent investigations of M. Tchernyschew quite at the north of Russia in Europe, in the Timan district of the Province of Archangel (*vide* Bull. Com. Géol. St. Pétersbourg, Tome x. p. 95–147). This explorer says: "All around the Timan chain extend immense plains occupied by mosses and marshes—region of Tundra. Striated pebbles abound everywhere, the quaternary glacial sea formed a vast gulf which extended as far as the line of the rivers Tzylma—Volonga. *Above* and transgressively on these deposits, sands and gravels are met with containing bones of *Elephas primigenius* and *Rangifer tarandus*."

Stronger evidence still, but of like character, comes from that so-called "home of the Mammoth"—North-East Siberia—where those vast accumulations of the bones of the Mammoth occur, which have always excited the greatest wonder and perplexity.

A Russian scientific expedition, under the auspices of the Academy of Sciences of St. Petersburg, has recently returned from the exploration of the New Siberian Islands and the mainland opposite, the Yana district, between the rivers Lena and Indigirka.

The scientific results of the expedition are in the course of being classified and published in the Memoirs of the Academy. Two of these Memoirs have already appeared, and a third has just been finished, bearing the title "The Bed of Fossil Ice in its Relation to the Deposits of Mammoth Carcases," by Baron de Toll.

I have not yet seen this last Memoir, but am indebted for my knowledge of its contents to the remarks and analysis of M. Schmidt when calling attention to the work at the meeting of the Academy on the 27th January, 1892.

It has been long known that in North Siberia, as well as in certain regions of North America, ice is met with in the ground under the form of a rock. To this ice several names have been given by different authors, and Baron de Toll proposes a new name, that of ice-rock (Steineis) or fossil ice. Of this he distinguishes three types: (1) that filling fissures in the ground; (2) the beds of ice in the valleys; (3) that of the continuous horizontal beds, very frequent in the New Siberian Islands, and upon the mainland opposite.

Upon this ice is *superposed* the recent argillaceous beds containing the bones of quaternary animals, and even their entire carcases.

Baron de Toll explains in the following way the finding of Mammoth bones and carcases in or upon this palæocrystic ice, in which, he says, they were *never* originally enclosed. In Spring, the waters scour in part these upper beds of clay, and the bones as well as the carcases fall to the bottom; it is thus that they are then found, quite at the bottom of the series of these beds.

The remains of a Mammoth found by M. de Toll in the Valley of Bar-Ourikh, to east of the town of Oust-Yansk, were found in the argillaceous beds which covered some thick beds of the valley ice. In the large island of Linkhof, one of the New Siberian group, he was shown the place where the carcase of a Mammoth had been found in a great cleft which had affected the upper stratum of clay as well as the upper layer of ice; the carcase had fallen to the bottom and was thus preserved in the ice. Analyzing in detail all the information relating to the famous Mammoth carcase brought by Mr. Adams (1806) to St. Petersburg from the mouth of the Lena, Baron de Toll arrives at the conclusion that this carcase had likewise fallen from above to the bottom of a crack in the ice, and was consequently found "in the middle of blocks of ice," according to Mr. Adams' expression.

This explanation gains support from the explorations of Dr. Dall, in Alaska (quoted by Prof. Wright, "Ice Age in North America," pp. 33–35), where the conditions are much the same as in Siberia, and where large numbers of the bones of the Mammoth also occur, and which are often found at the foot of the ice-cliffs in Eschscholtz Bay. Dr. Dall, after speaking of the vegetation of the tundra and

its luxuriant growth of herbage, adds: "The formation of the surrounding country shows no high land or rocky hills from which a glacier might have been derived and then covered with *débris* from their sides. The continuity of the mossy surface showed that the ice must be quite destitute of motion, and the circumstances appeared to point to one conclusion, that there is here a ridge of solid ice rising several hundred feet above the sea and higher than any of the land about it and *older* (italics mine) than the Mammoth and fossil horse, this ice taking upon itself the functions of a regular stratified rock."

It appears to me that this recent evidence shakes to its foundation that memorable phrase of Cuvier (Discours sur les Révolutions de la Surface du Globe), based on the assumed proof of Adams's Mammoth having been frozen up in the solid ice where found, suddenly and without warning. "Cette gelèe éternelle n'occupait pas auparavant les lieux où (les Mammouths) ils ont été saisis; car ils n'auraient pas pu vivre sous une pareille température. C'est donc le même instant qui a fait périr les animaux, et qui a rendu glacial le pays qu'ils habitaient. Cet événement a été subit, instantané, sans aucune gradation," etc.

If Sir Henry Howorth is able to prove his postulate of the pre-Glacial or pre-Boulder Clay advent of the Mammoth, there is, undoubtedly, I think, unimpeachable testimony of its existence long after the great cold, and up to the close of the Quaternary period, which would thus justify the application of Geoffroy Saint Hilaire's name of *Dicyclotherium* to the Mammoth, as the beast that had lived through two epochs.

V.—Additions to the Type Fossils in the Woodwardian Museum.

By Henry Woods, B.A., F.G.S.

In the "Catalogue of Type Fossils in the Woodwardian Museum, Cambridge," an account was given of all the types and described specimens known to be in the Museum at the end of November, 1891. The work is here continued to December 31st, 1892. The additions given consist of (1) Types presented during the year 1892; (2) Specimens described during the year; (3) Specimens which were in the Museum at the time of publication of the Catalogue but which were not then known to be types.

The authors who have described these specimens are, the late Prof. L. Agassiz, Mr. F. A. Bather, the late Dr. T. Davidson, the late Mr. E. W. Binney, the Rev. J. F. Blake, Mr. W. H. Hudleston, Prof. T. Rupert Jones, Prof. C. Lapworth, the late Count Münster, Dr. R. H. Traquair, the Rev. G. F. Whidborne, and Dr. H. Woodward.

To the list of collections in the Museum given on pages xiii and xiv of the Catalogue the following should be added:—

Binney Collection.—Carboniferous Plants, Old Red Sandstone Fishes, and various other fossils, collected by the late Mr. E. W. Binney, F.R.S., and presented by his son Mr. James Binney, B.A., in 1892.

The collection contains plants and fishes figured and described by Mr. Binney.

Carter Collection.—Portions of the collection of Mr. James Carter, F.R.C.S., presented at various times, and consisting chiefly of fossils from the Jurassic and Cretaceous formations of the neighbourhood of Cambridge, including several types.

Tawney Collection.—The collection of the late Mr. E. B. Tawney, M.A., consisting of fossils from various formations, the most important being from the Carboniferous Limestone of the neighbourhood of Bristol.

In the list which follows, as in the Catalogue itself, the only references given are those which relate to the actual specimens in the Museum. The types are distinguished by the letter [T].

PLANTÆ.

CALAMODENDRON COMMUNE, E. W. Binney, Obs. Struct. Foss. Plants. Carb. part i. (1868), pl. iv. f. 2, p. 24. *Coal Measures* (*Upper Brooksbottom Seam*); *Lancashire*. Binney Collection. [T.]

HALONIA REGULARIS, Lindley and Hutton, E. W. Binney, Obs. Struct. Foss. Plants Carb. part iii. (1872), pl. xv. f. 1–4, p. 89. *Coal Measures*; *near Dudley*. Binney Collection.

Binney, *ibid.* (1872), pl. xvi. f. 2–5, p. 90. *Coal Measures* (*Upper Brooksbottom Seam*); *Lancashire*. Binney Collection.

LEPIDODENDRON HARCOURTI, Witham, E. W. Binney, Obs. Struct. Foss. Plants Carb. part ii. (1871), pl. vii. f. 3–5, p. 46. *Coal Measures* (*Upper Foot Seam*); *near Oldham*. Binney Collection.

Binney, *ibid.* part iii. (1872), pl. xiii. f. 1, 3, p. 77. *Coal Measures*; *near Dudley*. Binney Collection.

LEPIDODENDRON VASCULARE, E. W. Binney, Quart. Journ. Geol. Soc. vol. xviii. (1862), pl. vi. f. 2–5, p. 106. *Coal Measures*; *Lancashire*. Binney Coll. [T.]

Binney, Obs. Struct. Foss. Plants Carb. part ii. (1871), pl. viii. f. 3, p. 49. *Coal Measures* (*Upper Foot Coal*); *near Oldham*. Binney Collection.

LEPIDOSTROBUS ? DUBIUS, E. W. Binney, Obs. Struct. Foss. Plants Carb. part ii. (1871), pl. ix. f. 3, p. 52. *Carboniferous* (*Blackband Ironstone*); *near Airdrie*. Binney Collection. [T.]

LEPIDOSTROBUS HIBBERTIANUS, E. W. Binney, Obs. Struct. Foss. Plants Carb. part ii. (1871), pl. x. f. 2, 2*a*, *b*, p. 55. *Lower Carboniferous* (*Burdiehouse Limestone*); *near Edinburgh*. Binney Collection. [T.]

LEPIDOSTROBUS RUSSELLIANUS, E. W. Binney, Obs. Struct. Foss. Plants Carb. part ii. (1871), pl. ix. f. 2, 2*a*, p. 51. *Carboniferous* (*Blackband Ironstone*); *near Airdrie*. Binney Collection. [T.]

SIGILLARIA VASCULARIS, E. W. Binney, Quart. Journ. Geol. Soc. vol. xviii. (1862), pl. iv. f. 2, 4, 5, pl. v. f. 2–4, p. 106. *Coal Measures*; *Lancashire*. Binney Collection. [T.]

E. W. Binney, Obs. Struct. Foss. Plant Carb. part iii. (1872), pl. xiv. f. 4–6, p. 81. *Coal Measures* (*Bullion Seam*); *Spa Clough*, *near Burnley*. Binney Coll.

Binney, *ibid.* part iv. (1875), pl. xix. f. 1, pl. xx. f. 1, p. 136. *Coal Measures* (*Hard Seam*); *South Owram*, *Yorks*. Binney Collection.

Binney, *ibid.* part iv. (1875), pl. xxiii. f. 1, p. 141. *Coal Measures* (*Bullion Seam*); *Clough Head*, *near Burnley*. Binney Collection.

CRINOIDEA.

CYATHOCRINUS ACINOTUBUS, Angelin, F. A. Bather, Ann. Mag. Nat. Hist. ser. 6, vol. ix. (1892), pl. xiii. f. 3–5, p. 213. *Wenlock Limestone*; *Dudley*. Fletcher Collection.

MASTIGOCRINUS LOREUS, F. A. Bather, Ann. Mag. Nat. Hist. ser. 6, vol. ix. (1892), pl. xi. f. 3, pp. 194–202. *Wenlock Limestone*; *Dudley*. Fletcher Collection. [Specimen referred to in Catalogue as *Cyathocrinus arboreus*, Salter.] [T.]

BRACHIOPODA.

DISCINA ANNULOSA, T. Davidson, Brit. Foss. Brach. vol. iv. (1876), pl. x. f. 15, 15*a*, *b*, p. 87. *Cornbrash*; *Scarborough*. Leckenby Collection. [T.]

RHYNCHONELLA SPEETONENSIS, Davidson. The specimen referred to on page 60 of Catalogue is probably in the Leckenby Collection.

TEREBRATULA DEPRESSA, Lamarck, T. Davidson, Brit. Foss. Brach. vol. iv. (1874), pl. iv. f. 2, p. 40. *Lower Greensand*; *Upware*.

LAMELLIBRANCHIATA.

ACTINOPTERIA CRENATISSIMA (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. ix. f. 9, 9*a*, p. 77. *Pterinea crenatissima*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

ACTINOPTERIA DILATATA (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. vi. f. 9, 9*a*, 10, pl. vii. f. 1, 1*a*, 3, p. 64. *Pterinea dilatata*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

ACTINOPTERIA HIRUNDELLA (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. vii. f. 4, 4*a*, *b*, p. 61. *Aviculopecten hirundella*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

ACTINOPTERIA JUSTI (Freck), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. vii. f. 12, 12*a*, p. 70. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

ACTINOPTERIA PLACIDA (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. vii. f. 5, 5*a*, 9, 10, 10*a*, 11, 11*a*, p. 67. *Pterinea placida* and *P. obovata*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

ACTINOPTERIA? ROBERTSI, G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. vi. f. 2, 2*a*, 3, 3*a*, 4, p. 60. *Middle Devonian*; *Lummaton*. Figs. 2 and 3 presented by the Rev. G. F. Whidborne, M.A. [T.]

ACTINOPTERIA RUDIS (Phillips), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. viii. f. 4, 6, 6*a*, p. 73. *Pterinea rudis*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889) p. 78. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

ACTINOPTERIA WURMI (Römer), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. viii. f. 2, 3, 5, p. 71. *Pterinea wurmi*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 78. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

ALLORISMA DUBIUM (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. i. f. 3. p. 4. *Edmondia? dubia*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

AVICULOPECTEN AVIFORMIS, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79, and Devonian Fauna S. Eng. vol. ii. (1892), pl. x. f. 7, 7*a*. 8, 8*a*, p. 85. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

Aviculopecten comma, v. Crenipecten? comma.

——— *consolans*, v. Pterinopecten consolans.

——— *cybele*, v. Pterinopecten cybele.

——— *gracilinus*, v. Pterinopecten gracilinus.

——— *hirundella*, v. Actinopteria hirundella.

CONOCARDIUM CLATHRATUM, d'Orbigny. G. F. Whidborne, Devonian Fauna, S. Eng. vol. ii. (1892), pl. i. f. 17, 17*a*, 18, 18*a*, 19, 19*a*, *b*, *c*, p. 18. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

CONOCARDIUM FRATER, G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. ii. f. 10, 10*a*, p. 30. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

CONOCARDIUM PUGNANS (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. ii. f. 4, 4*a*–*c*, 5, 5*a*, p. 24. *Pleurorhynchus pugnans*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

CONOCARDIUM VILLMARENSE (d'Archiac and de Verneuil), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. ii. f. 8, 8*a–c*, 9, p. 28. *Pleurorhynchus villmarensis*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

CRENIPECTEN? COMMA (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. x. f. 4, 4*a*, 5, 5*a*, p. 88. *Aviculopecten comma*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

Cypricardia ensiformis, v. Cypricardinia ensiformis.

——— *guttata*, v. Cypricardinia reticulata.

——— *neglecta*, v. Cypricardinia scalaris.

CYPRICARDINIA ENSIFORMIS (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. i. f. 15, p. 13. *Cypricardia ensiformis*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

CYPRICARDINIA RETICULATA (Phillips), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. i. f. 11, 11*a*, p. 11. *Cypricardia guttata*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [*C. guttata*, T.]

CYPRICARDINIA SCALARIS (Phillips), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. i. f. 7, 8, p. 5. *Cypricardia neglecta*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

Edmondia? dubia, v. Allorisma dubium.

GOSSELETIA? sp., G. F. Whidborne. Devonian Fauna S. Eng. vol. ii. (1892), pl. iv. f. 6, 6*a*, p. 50. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

HOPLOMYTILUS CRASSUS, Sandberger, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 78, and Devonian Fauna S. Eng. vol. ii. (1892), pl. iv. f. 3, 3*a*, p. 44. *Middle Devonian*; *Wolborough*.

Myalina elliptica. v. Rutotia elliptica.

MYALINA LUNA, G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. iv. f. 1. p. 48. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

NUCULA PROTEI, Münster, G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. iii. f. 3, 3*a*, p. 37. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

PLETHOMYTILUS RETORTUS, G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. v. f. 1, p. 52. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

Pleurorhynchus pugnans, v. Conocardium pugnans.

——— *villmarensis*, v. Conocardium villmarense.

PROTOSCHIZODUS? TRIGONELLUS, G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. iii. f. 2, p. 36. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

Pterinea crenatissima, v. Actinopteria crenatissima.

——— *dilatata*, v. Actinopteria dilatata.

——— *placida*, v. Actinopteria placida.

——— *obovata*, v. Actinopteria placida.

——— *rudis*, v. Actinopteria rudis.

——— *wurmi*, v. Actinopteria wurmi.

PTERINOPECTEN CONSOLANS (Barrande), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. ix. f. 11, p. 83. *Aviculopecten consolans*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 78. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

PTERINOPECTEN CYBELE (Barrande), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. viii. f. 9, 9*a*, 10, 10*a*, p. 82. *Aviculopecten cybele*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 78. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

PTERINOPECTEN GRACILINUS (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. ix. f. 10, p. 80. *Aviculopecten gracilinus*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Wolborough*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

RUTOTIA ELLIPTICA (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. ii. (1892), pl. iv. f. 9, 9*a*, 10; pl. v. f. 2, 2*a*, 4, 4*a*, 6, 7, 8, 8*a*, p. 55. *Myalina elliptica*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 79. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

GASTEROPODA.

BELLEROPHON HICKSI, G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1892), pl. xxxi. f. 7, 7*a*, *b*, p. 326. *Middle Devonian*; *Wolborough*. Presented by G. M. Hicks, Esq. [T.]

BELLEROPHON LINEATUS [Goldfuss, MS.], de Ferussac and d'Orbigny, G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1892), pl. xxxi. f. 3, 3*a*, *b*, p. 321. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

DIRHACHIS ATAVUS, G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1891), pl. xxv. f. 15, p. 157. *Middle Devonian*; *Chudleigh*. [T.]

DISCOHELIX SPINOSUS [Wright, MS.], W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xxv. f. 8, p. 317. *Inferior Oolite* (*Concavus-bed*); *Bradford Abbas*. [T.]

EUOMPHALUS? ARANEIFER, G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1892), pl. xxiv. f. 13, p. 253. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

EUOMPHALUS FENESTRALIS, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 30, and Devonian Fauna S. Eng. vol. i. (1892), pl. xxv. f. 2, p. 254. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

EUOMPHALUS GERMANUS (Phillips), G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 30, and Devonian Fauna S. Eng. vol. i. (1892), pl. xxv. f. 5, 5*a*, *b*, p. 256. *Middle Devonian*; *Wolborough*.

Euomphalus serpula, v. Phanerotinus militaris.

LITTORINA UNICARINATA [Bean, MS.], W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl xxiii. f. 1, p. 289. *Dogger Series*; *Blue Wyke*. Leckenby Collection. [Specimen referred to in Catalogue, p. 105.] [T.]

MACROCHILINA SUBCOSTATA (Schlotheim), G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1891), pl. xvi. f. 2, 2*a*, p. 159. *Macrocheilus subcostatus*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 30. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

MURCHISONIA MARGARITA, G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1892), pl. xxx. f. 20, 20*a*, p. 318. *Middle Devonian*; *Chudleigh*. [T.]

MURCHISONIA TURBINATA (Schlotheim), G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1892), pl. xxix. f. 8, 15; pl. xxx. f. 1, 2, 4, p. 306. *Middle Devonian*; *Chudleigh*. Presented by the Rev. G. F. Whidborne, M.A.

NATICA DUNDRIENSIS (Tawney), W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xx. f. 11*b*, *c*, p. 262. *Inferior Oolite*; *Dundry*.

NATICA LORIERI, d'Orbigny, var. CANINA, W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xx. f. 9*a*, p. 260. *Dogger Series*; *Blue Wyke*. Leckenby Collection. [Specimen referred to in Catalogue, p. 108, as *Natica adducta*, Phillips, var. *canina*.] [var. canina T.]

NATICA LORIERI, d'Orbigny, var. PROXIMA, W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xx. f. 7, p. 260. *Dogger Series*; *Blue Wyke*. Leckenby Collection. [Specimen referred to in Catalogue, p. 108, as N. proxima.] [var. proxima, T.]

NATICA PUNCTURA (Bean) (? bajocensis, d'Orbigny), W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xx. f. 14, p. 264. *Dogger Series*; *Blue Wyke*. Leckenby Collection. [Specimen referred to in Catalogue, p. 109.]

PHANEROTINUS MILITARIS, G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1892), pl. xxv. f. 11, p. 259. *Euomphalus serpula*, de Koninck, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 30. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

PLEUROTOMARIA BISCHOFFI, Goldfuss, G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1892), pl. xxxi. f. 1, 1*a*, p. 305. *Middle Devonian*; *Lummaton*. Tawney Collection.

PLEUROTOMARIA CHUDLEIGHENSIS, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 30, and Devonian Fauna S. Eng. vol. i. (1892), pl. xxviii. f. 2, p. 292. *Middle Devonian*; *Chudleigh*. [T.]

PLEUROTOMARIA SUBIMBRICATA, G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1892), pl. xxviii. f. 6, p. 293. *Middle Devonian*; *Lummaton*. Tawney Collection. [T.]
Another specimen, Whidborne, *ibid.* pl. xxviii. f. 7, p. 293. *Pleurotomaria imbricata*, F. McCoy (*non* Römer), Brit. Palæoz. Foss. (1885), p. 393. *Middle Devonian*; *Wolborough*. [T.]

PLEUROTOMARIA VICTRIX, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 30, and Devonian Fauna S. Eng. vol. i. (1892), pl. xxviii. f. 15, 16, p. 301. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A. [T.]

PSEUDOMELANIA PROCERA (Deslongchamps), W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xviii. f. 2, p. 237. *Dogger Series*; *Blue Wyke*. Leckenby Collection. [Specimen referred to in Catalogue, p. 101, as *Chemnitzia lineata* (Sowerby).]

PSEUDOMELANIA SCARBURGENSIS ? (Morris and Lycett), W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xix. f. 3, p. 243. *Scarborough Limestone*; *Scarborough*. Leckenby Collection. [Specimen referred to in Catalogue, p. 101, as *Chemnitzia lineata-procera*, var. *scarburgensis*, Morris and Lycett.]

ROTELLINA ? HELICINA (Münster), G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1892), pl. xxvi. f. 10, 10*a*, p. 269. *Middle Devonian*; *Lummaton*. Tawney Collection.

SOLARIUM SUBVARICOSUM, W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xxvi. f. 12, p. 324. *Inferior Oolite*; *Yeovil*. Walton Collection. [T.]

STRAPAROLLUS EXSERTUS, W. H. Hudleston, Brit. Jurass. Gasterop. Inf. Ool. (1892), pl. xxvi. f. 4, p. 320. *Inferior Oolite*; *probably from Stoford*. [T.]

POLYPLACOPHORA.

? HELMINTHOCHITON PAPILIO (Whidborne), G. F. Whidborne, Devonian Fauna S. Eng. vol. i. (1891), pl. xxxi. f. 16, p. 334. *Chiton papilio*, G. F. Whidborne, GEOL. MAG. Dec. III. Vol. VI. (1889), p. 30. *Middle Devonian*; *Lummaton*. Presented by the Rev. G. F. Whidborne, M.A.

CEPHALOPODA.

ÆGOCERAS DIVERSUM (Simpson), J. F. Blake, in R. Tate and J. F. Blake, The Yorkshire Lias (1876), pl. viii. f. 3, p. 282. *Lias* (*probably capricornus-zone*); *Whitby*. Leckenby Collection.

ÆGOCERAS ? FINITIMUM [Bean, MS.], J. F. Blake, in R. Tate and J. F. Blake, The Yorkshire Lias (1876), pl. vi. f. 9, p. 273. *Lower Lias* (? *bucklandi-zone*); *Robin Hood's Bay*. Leckenby Collection. [T.]

ÆGOCERAS SAGITTARIUM, J. F. Blake, in R. Tate and J. F. Blake, The Yorkshire Lias (1876), pl. vii. f. 2*a*, *b*, p. 276. *Lias* (*jamesoni*) *zone*; *Robin Hood's Bay*. Leckenby Collection. [Specimen referred to in Catalogue, p. 121, as *Ammonites* (*Ægoceras*) *acuticostatum*.] [T.]

ÆGOCERAS SOCIALE (Simpson), J. F. Blake, in R. Tate and J. F. Blake, The Yorkshire Lias 1876), pl. vii. f. 6, p. 278. *Lias* (*armatus-zone*); *Robin Hood's Bay*. Leckenby Collection.

ÆGOCERAS VALIDUM (Simpson), J. F. Blake, in R. Tate and J. F. Blake, The Yorkshire Lias (1876), pl. vii. f. 3, p. 278. *Middle Lias*; *Robin Hood's Bay*. Leckenby Collection.

TRILOBITA.

OLENELLUS CALLAVEI, C. Lapworth, GEOL. MAG. Dec. III. Vol. V. (1888), p. 485, and "Nature," vol. xxxix. (1888) p. 213, and GEOL. MAG. Dec. III. Vol. VIII. (1891), pl. xiv. f. 1–17, 21–23, p. 530. *Comley Sandstone*; *Comley Quarry*. [T.]

PHYLLOCARIDA.

APTYCHOPSIS ANGULATA ? (Baily), T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xv. f. 17, p. 111. *Brathay Flags*; *Nanny Lane, Troutbeck*. Presented by J. E. Marr, Esq., F.R.S. [Specimen referred to in Catalogue, p. 134, as *Aptychopsis* sp.]

APTYCHOPSIS CORDIFORMIS, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xv. f. 2, p. 103. *Lower Wenlock*; *Rebecca Hill, Ulverston.* [Specimen referred to in Catalogue, p. 133.] This specimen is the type of *Peltocaris anatina*, Salter. [T.]

APTYCHOPSIS LAPWORTHI, Woodward, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xv. f. 3, p. 107. *Skelgill Beds*; *Skelgill.* Presented by J. E. Marr, Esq., F.R.S. [Specimen referred to in Catalogue, p. 133.]

CARYOCARIS MARRI, Hicks, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xiv. f. 18, p. 92. *Upper Arenig*; *Nantlle Tramway.* Presented by J. E. Marr, Esq. [Specimen referred to in Catalogue, p. 134.] [T.]

CARYOCARIS WRIGHTI, Salter, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xiv. f. 15, p. 90. *Skiddaw Slates*; *Cumberland.*

CARYOCARIS? sp., T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xvii. f. 9–11, p. 124. *Upper Arenig*; *Nantlle Tramway.* Presented by J. E. Marr, Esq., F.R.S.

CERATIOCARIS? sp., T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xvii. f. 12, p. 124. *Skelgill Beds*; *Skelgill.* Presented by J. E. Marr, Esq., F.R.S.

DISCINOCARIS BROWNIANA, Woodward, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xvi. f. 17–19, p. 119. *Skelgill Beds*; *Lower Footbridge, Skelgill.* Presented by J. E. Marr, Esq., F.R.S.

DISCINOCARIS GIGAS, Woodward, T. R. Jones and H. Woodward, GEOL. MAG. Dec. III. Vol. I. (1884), p. 351, and Rep. Brit. Assoc. 1884 (1885), p. 80, and Brit. Palæoz. Phyllop. (1892), pl. xvii. f. 2, p. 122. *Skelgill Beds*; *Skelgill Beck.* Presented by J. E. Marr, Esq., F.R.S.

HYMENOCARIS? LATA, Salter, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), p. 80, woodcut 4. *Upper Tremadoc*; *Garth, Portmadoc.* [Specimen referred to in Catalogue, p. 134, as *Ceratiocaris? lata.*] [T.]

HYMENOCARIS VERMICAUDA, Salter, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xiii. f. 1, 4, 5, 6, pp. 74–78. *Middle Lingula Flags*; *Borth, Portmadoc.* [Specimen referred to in Catalogue, p. 136.]
Another specimen, Jones and Woodward, *ibid.* (1892), pl. xiii. f. 12, p. 77. *Lingula Flags*; *Wern.*
Another specimen, Jones and Woodward, Rep. Brit. Assoc. 1883 (1884), p. 221, and Brit. Palæoz. Phyllop. (1892), pl. xiii. f. 7, p. 79. *Lingula Flags*; *Caen-y-Coed, Maentwrog.*

LINGULOCARIS LINGULÆCOMES, Salter, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), p. 81. *Lingula Flags*; *Garth, Portmadoc.* [Specimen referred to in Catalogue, p. 136.] [T.]

LINGULOCARIS SALTERIANA, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), p. 83. *Lower Lingula Flags*; *Caen-y-Coed, near Maentwrog.*
Another specimen, Jones and Woodward, *ibid.* (1892), p. 83. *Brathay Flags*; *E. side of Long Sleddale.* [Specimens referred to in Catalogue, p. 136.]

PELTOCARIS ANATINA, Salter, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xvi. f. 5, p. 115. *Skelgill Beds*; *W. side of Long Sleddale.* Presented by J. E. Marr, Esq., F.R.S. [Specimen referred to in Catalogue, p. 136.]

PELTOCARIS PATULA, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xvi. f. 11, p. 116. *Skelgill Beds*; *Skelgill.* Presented by J. E. Marr, Esq., F.R.S. [Specimen referred to in Catalogue, p. 136, as *Peltocaris* sp.] [T.]

SACCOCARIS MAJOR (Salter), T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xiv. f. 6, p. 84. *Lower Lingula Flags*; *Caen-y-Coed, near Maentwrog.* Presented by D. Homfray, Esq. [Specimen referred to in Catalogue, p. 136.]

SACCOCARIS MINOR, T. R. Jones and H. Woodward, Brit. Palæoz. Phyllop. (1892), pl. xiv. f. 7–9, p. 86. *Arenig Beds*; *Craig-yr-hyrddod, Arenig.* Presented by Professor Hughes. [Specimens referred to in Catalogue, p. 137.] [T.]
Another specimen (?), Jones and Woodward, *ibid.* (1892), pl. xiv. f. 10, p. 88. *Lingula Flags*; *Wern, Portmadoc.*

DECAPODA.

ÆGER LONGIROSTRIS, G. G. Münster, Petrefactenkunde (1839), pl. xxvi. p. 67. *Lithographic Slate*; *Eichstädt.* Münster Collection. [T.]

ALVIS OCTOPUS, G. G. Münster, Petrefactenkunde, heft. iii. (1840), pl. i. f. 1, p. 20. *Lithographic Slate*; *Eichstädt.* Münster Collection. [T.]

BOLINA ANGUSTA, G. G. Münster, Petrefactenkunde (1839), pl. ix. f. 14, p. 24. *Lithographic Slate*; *Solenhofen.* Münster Collection. [T.]

ERYON LATUS, G. G. Münster, Petrefactenkunde (1839), pl. v. f. 6, p. 9. *Lithographic Slate*; *Eichstädt.* Münster Collection. [T.]

ERYON MEYERI, G. G. Münster, Petrefactenkunde (1839), pl. iii. f. 1, p. 6. *Lithographic Slate*; *Solenhofen.* Münster Collection. [T.]

ERYON OVATUS, G. G. Münster, Petrefactenkunde (1839), pl. vii. f. 3, p. 12. *Lithographic Slate*; *Solenhofen.* Münster Collection (counterpart). [T.]

ERYON SCHUBERTI (Meyer), G. G. Münster, Petrefactenkunde (1839), pl. vii. f. 9, p. 13. *Lithographic Slate*; *Solenhofen.* Münster Collection (counterpart.)

ERYON SUBPENTAGONUS, G. G. Münster, Petrefactenkunde (1839), pl. vi. f. 2, p. 10. *Lithographic Slate*; *Kelheim.* Münster Collection. [T.]

GLYPHÆA ELONGATA, G. G. Münster, Petrefactenkunde (1839), pl. viii. f. 9, p. 18. *Lithographic Slate*; *Solenhofen.* Münster Collection. [T.]

GLYPHÆA LÆVIGATA, G. G. Münster, Petrefactenkunde (1839), pl. ix. f. 5, p. 20. *Lithographic Slate*; *Solenhofen.* Münster Collcetion. [T.]

MEGACHIRUS BAJERI (Bronn), G. G. Münster, Petrefactenkunde (1839), pl. xiii. f. 7, p. 33. *Lithographic Slate*; *Solenhofen.* Münster Collection.

PALINURINA INTERMEDIA, G. G. Münster, Petrefactenkunde (1839), pl. xiv. f. 9, p. 37. *Lithographic Slate*; *Solenhofen.* Münster Collection. [T.]

PISCES.

ELONICHTHYS BINNEYI, R. H. Traquair, GEOL. MAG. Dec. III. Vol. V. (1888), p. 251. *Lower Coal Measures*; *Stanton, Derbyshire.* Binney Collection. [T.]

GYRODUS GRACILIS, G. G. Münster, Petrefactenkunde, heft. iii. (1840), pl. viii. f. 2*a*, *b*, p. 128. *Lithographic Slate*; *Kelheim.* Münster Collection. [T.]

GYRODUS RUGOSUS [Münster MS.], L. Agassiz, Poiss. Foss. vol. ii. (1839), pl. lxix. f. 1–4, p. 227. *Lithographic Slate*; *Kelheim.* Münster Collection. [T.]

HOLOPTYCHIUS SAUROIDES, Williamson, E. W. Binney, Trans. Manchester Geol. Soc. vol. i. (1841), pl. v. f. 8, 10, p. 165. *Coal Measures*; *Pendleton.* Binney Collection.

MEGALICHTHYS HIBBERTI, Agassiz, E. W. Binney, Trans. Manchester Geol. Soc. vol. i. (1841), pl. v. f. 4, p. 162. *Coal Measures*; *Pendleton.* Binney Collection.

MESOLEPIS MICROPTERUS, R. H. Traquair, Trans. Roy. Soc. Edinb. vol. xxix. (1879), p. 356. *Lower Coal Measures* (*Dalemoor Rake Ironstone*); *Stanton-by-Dale, Derbyshire.* Binney Collection. [T.]

PALÆONISCUS EGERTONI [Agassiz, MS.] (Egerton), E. W. Binney, Trans. Manchester Geol. Soc. vol. i. (1841), pl. v. f. 12, p. 166. *Coal Measures*; *Pendleton.* Binney Collection.

NOTICES OF MEMOIRS.

I.—THE MOUNTAINS OF SCOTLAND. By MARCEL BERTRAND, Professor in the École des Mines, Paris. Translated by G. A. LEBOUR, M.A., Professor of Geology in the Durham College of Science, Newcastle. From the "Revue générale des Sciences pures et appliquées," No. 23, December 15, 1892.

THE chief impression carried away by all visitors to Scotland is that Scotland is a country of mountains. Notwithstanding the somewhat low altitude of the heights (the tallest peak, Ben Nevis, does not reach 1400 metres), one could at many points imagine oneself in the upland valleys or on the higher plateaux of the Alps.

Latitude has something to do with this. As is the case with the flora, with which its aspects are associated, so there is in the scenery a northern character which in many ways reminds one of the Alpine character. The impression produced corresponds no less with a geological truth: Scotland is one of the countries in which are to be found the best marked traces of those great movements of the earth's crust by which mountains have been created. It is the witness of an ancient chain which ran on into Norway, of which the central core must have been located in the Grampian *massif*, and of which the slightly diverging subordinate ranges were directed to the north-east, towards Edinburgh, and nearly to the north along the western coast, facing the Hebrides. This chain is doubly interesting, first because of its size and of the complex accidents which the work of the last ten years has made known within it, and also because of its great antiquity: the *Caledonian Chain* is one of the oldest, if not the oldest, which it is given us to reconstruct. One finds oneself there face to face with movements dating from the dawn of primary times, that is, from a time when theoretically [1] the mean thickness of the crust affected by these movements must have been sensibly less than at the time of the formation of the Alps. Was there in this an appreciable cause of difference in the behaviour of the phenomena? What analogies as regards the whole and what modifications as to details will be brought out by a comparison with the Alps? No doubt the interpretation of these differences will always remain a little arbitrary; but it is enough to indicate the question to which they may belong to show the interest which they possess. If it be added that the investigations carried out in the North of Scotland seem to be of a nature to throw some light on the still so obscure subject of the gneissose rocks, it will be seen that they are of an order far surpassing that of a mere regional description. They are, I think, among those that deserve to be presented in some detail to the readers of the "Revue."

Thanks to a courteous invitation from Sir Archibald Geikie, Director-General of the Geological Survey of Great Britain, we were enabled, M. de Margerie and I, to study last summer the region of Assynt, under the guidance of Mr. Peach, who specially directs the work of the Scotch map.[2] Mr. Peach made us verify the principal sections published; we saw with him the irrefutable evidence on which they are based, and we admired the minute accuracy of the survey. Mr. Peach said to us at starting: "I do not think that there is now in the whole of Great Britain any region better or more completely known than that which we are about to visit." We may add, after what we have seen, that in

[1] The theory of the cooling of the globe is not free from objections; it is necessary to admit that the earth is at the same time homogeneous, solid, and plastic. These are hypotheses which are certainly not all exact and that are admissible as approximations only. I think, however, that the formulæ may be considered as indicating the drift of the phenomena.

[2] We had the good fortune of making this excursion in the company of Baron von Richthofen, the eminent Berlin professor, Professors Hughes and Sollas, and Messrs. Harker and Watts.

no other part of Europe has it been possible for geological mapping to be carried further, or to do greater honour to its authors.

I. Before describing the results of the most recent work, it will be well to say a few words as to that which preceded it. This part of Northern Europe has long been famous for the discussions to which it has given rise. The discovery of fossils in the Durness limestone in 1854 induced Murchison to study the region, and it was he who drew attention to the peculiarities of its structure; a thick series of sediments, quartzites and limestones, rests to the west on the gneisses of the coast, and dips regularly, and at a somewhat low angle, beneath an enormous mass of micaceous schists and of other gneisses, without presenting anywhere indications of interruption or unconformity. Murchison concluded that the upper gneisses were "newer gneisses," and that these must be regarded as Silurian deposits, overlying the fossiliferous beds, and metamorphosed at a later period.

Professor Nicol, of Edinburgh, who accompanied Murchison on his first visit, was the first, on returning to the same investigation in the following years, to propose a different interpretation. He thought that the Silurian quartzites and limestones of the base were repeated several times by folds and by faults; that the conformity with the upper gneisses was only local and apparent, and that in reality there occurred between them a fault along which the gneisses of the east had been pushed over the Silurian. These remarkable views—destined to brilliant confirmation in the future—were supported by a comparison with the known phenomena of the Alps. They were unfortunately not accompanied by those decisive proofs which would at that time alone have caused such innovations to be accepted. Murchison's authority prevailed, and for more than twenty years the existence in Scotland of Silurian gneisses was admitted without discussion, and unreservedly.

The question, taken up from 1878, in the notes of Messrs. Hicks, Bonney, Hudleston, and Callaway, entered upon a new phase upon the publication of the memorable Memoir by Professor Lapworth, entitled "The Secret of the Highlands.[1] Professor Lapworth, in 1882 and 1883, set himself to make a detailed survey of the Durness and Erriboll districts; he was thus led to revive the views of Nicol, but supported this time by decisive proofs.

These proofs were singularly difficult to discover. Fossils were wanting, or nearly so; it was necessary to carry out a stratigraphical study based upon lithological characters only, and in order to do this it was requisite that a sufficient number of precise horizons should be singled out in a series very uniform in appearance, or at least in which there were only two very distinct members. I remember the astonishment, I might almost say the terror, which seized M. de Margerie and myself the first day, when Mr. Peach pointed out to us the characters which differentiated these successive horizons; their apparent insignificance, their almost intangible

[1] Geol. Mag. Decade II. Vol. X. 1883, pp. 120, 133, and 137; and Proc. Geol. Assoc. 1884, vol. viii. p. 438.

nature, immediately called forth two thoughts; the first, that one would have been incapable of distinguishing them oneself, and the second, that one must be very bold to establish such grandiose results upon bases of this kind. But these characters, recognized at first in a limited field, were found, ever the same, without modification, for a distance of 150 kilometres. Messrs. Peach and Horne have multiplied the number of these horizons, and their subdivisions, as well as the chief divisions of Professor Lapworth, are repeated in the entire region with the same precision. Each proof, taken separately, would seem of small value: but they are cumulative, and together form an indestructible whole.

Professor Lapworth has shown that the apparent enormous thickness of the system was formed by a small number of beds, "piled again and again," and indefinitely repeated, always with the same direction of dip. After this it becomes natural to ascribe the presence of this gneiss above the Silurian to this same phenomenon of "heaping." There the proofs are of another order, and are drawn from the nature of these gneisses and mica-schists; for it can be shown that they have been subjected to tremendous movements, that their particles have undergone a true *re-arrangement*, which, however, allows the recognition here and there of certain portions, less altered, of the ancient gneiss of the coast or of the Silurian divisions. It is to be looked upon as a heterogeneous mass, crushed and pounded by mechanical action and reproducing, in consequence of a sort of general cleavage, the appearance of primitive stratification.

In this way the existence of phenomena, hitherto acknowledged only in certain portions of the Alps, and in the Franco-Belgian coal-field, became recognized in the North of Scotland; the displacement and horizontal carriage of thick superficial masses over several kilometres. Similar examples are now abundant; one led to the other. But ten years ago this was not the case, and I have been told that Professor Lapworth, seized by a kind of fever in facing the consequences which he saw successively opening out before him, in his dreams thought himself caught up in the cogs of these tremendous movements, and crushed along the planes of thrust.

Few geological careers exhibit successes comparable to those of Professor Lapworth. In the South of Scotland, it was by means of Graptolites—lowly organisms of which the palæontological value might appear but slight—that he established horizons in a series that had defied all efforts, and the zones determined in the little corner of Dobb's Linn are now detected all over Europe, and even in America. For the North of Scotland it is with still more insignificant data, with tracks of worms, with lithological differences of colour and grain, that he has fixed his horizons—horizons which, here again, have been found to possess unexpected constancy and extension. By the aid of these tools, forged by himself, and which others would have disdained, he has given the key to the geology of two great provinces of Scotland; he has thus done for the stratigraphy of the Highlands what Sir Archibald Geikie has done for the history of the eruptions of that region, and both names will

remain associated with one of the most brilliant phases of Scottish geology.

II. The share of those who have followed Professor Lapworth is sufficiently handsome to enable me, without depreciating their merits, to insist upon those of him who was the *precursor*. The earlier work had shown general affinity to Alpine structure. That of Messrs. Peach and Horne, whilst adding precision to the resemblance, at the same time has brought out differences of which the interest is considerable.

The Geological Survey, although rather prejudiced in favour of the old views, hastened to undertake the general study of the region where the phenomena pointed out by Professor Lapworth could be verified and followed out. Already, in 1884, Mr. Peach, placed in charge of these investigations, was able to invite the Director-General to come and ratify the decisive results which had been obtained, and Sir Archibald Geikie, abandoning the opinion he had hitherto held, lost no time in accepting the evidence of the facts, and in widely announcing the change of view by publishing in "Nature"[1] the conclusions to which the officers of the Survey had been led, step by step, and almost in spite of themselves. But it was only in 1888 that a detailed report was issued embracing the whole of the observations made by Messrs. Peach, Horne, Gunn, Clough, Hinxman, and Cadell.[2] Since then, the observations have been completed, but the Report of 1888 still represents the principal features of the results obtained.

These results are remarkable for more reasons than one. On hearing that the mountains of Scotland showed traces of horizontal displacements comparable to those of more recent mountain ranges, it was possible to suppose that the ancient chain would prove to be constructed on exactly the same plan as the Alps. Later, on finding in the sections of Messrs. Peach and Horne important differences between them and the classical types of Switzerland, it was still possible to believe that these differences might be more apparent than real, and that by varying the method of interpretation they might be reconciled. All such expectation must, I think, be given up; the differences are real and profound; their causes and their theoretical importance can be discussed, but their existence cannot be contested.

To begin with, there are three great planes—or better, three great independent surfaces of "push" or carriage (thrust planes). Each of these has produced horizontal displacements of several kilometres. For the third, the most easterly, these displacements attain 15 kilometres. The first two have brought into superposition above the normal series only beds similar to those which they overlie; the third, on the contrary, has brought a different series into superposition—precisely that of the ancient "recent gneisses" of Murchison. In places, the last thrust plane comes to override the first two; so that there is then a three-storied edifice, the two lower

[1] "Nature," 13th November, 1884.

[2] Quart. Journ. Geol. Soc. 1888, p. 378.

stories built up of the same materials as the basement, and the third formed of different materials. What is more extraordinary, but nevertheless appears to be certain (though I have seen but one example of it, and could not devote sufficient time to its examination), is that the third story does not everywhere rest upon the second, but cuts across the latter obliquely so as to lie upon the first, or even immediately upon the basement. This is an extraordinary complication, of which other instances have not been recognized. Series of thrust planes, arranged one behind the other in *échelon*, and each producing horizontal displacements of several kilometres, are well known, notably in Provence. But each of these thrusts corresponds with a distinct fold; each one has its own domain, and does not trespass upon its neighbour's. In Scotland one cannot resist the impression that one is face to face with a unique phenomenon, and that the division in three folds, each forming one of the three stories, is non-existent.

There is, however, a difference still more important in my eyes; it is the absence of *inverted beds*. In the Alps and in Provence what characterizes these phenomena of horizontal movements is the more or less intermittent presence of beds succeeding one another in inverse order, the oldest above, the most recent below. These inverted beds are at the same time generally *dragged out*; that is to say, the normal thickness of the divisions is there very greatly reduced. It is these beds that seem to give the clue to the phenomenon and that have allowed Professor Heim to formulate his theory, comparing it to the unfolding of a fold, the base of which, forced to stretch over a larger area, undergoes a kind of rolling out. It would be very easy, it is true, to answer that in Scotland the diminution in thickness has proceeded to zero; that the dragging out process has been carried on so as to become suppression, and the same mechanism can still be resorted to. But there is something further: above each thrust plane there are in Scotland also beds in an abnormal position, only this position is of quite another kind; these beds are oblique to the thrust plane and are indefinitely repeated in consequence of a series of small faults with a hade a little larger than the dip of the beds. In other words, each of our three stories has a *floor*; but this floor, instead of being formed of planks parallel to the base of the story, is as if it had been formed by cutting these planks into slices obliquely uptilted. All these slices are similar among themselves, always sloping to the east, *i.e.* towards the side whence the movement has come, and *the beds are never inverted*. The small separating faults are usually not very obvious, and consequently, finding similar beds recurring over large areas, without apparent horizons and always dipping in the same direction, one would be led to attribute to them impossible thicknesses. It is here that the utility of the subdivisions introduced in the series becomes manifest: one is confronting a set of *numbered* beds, the numbers of which, though not very distinct, are yet well known and are everywhere recognizable by minute examination. This examination has been carried out in an extraordinarily careful and conscientious

manner. In the region visited by us, in the midst of this maze of beds always resembling one another and repeated in narrow compartments, we did not come across a single compartment of which Mr. Peach was not able to show us the detail represented on his plottings on a scale of $\frac{1}{10560}$; not one bed of which Mr. Peach could not beforehand tell us the number.

The arrangement that I have been attempting to describe is exactly what Professor Suess has called *schuppen-structur* (imbricated structure), and it is to be seen produced, in the Bernese Jura for instance, as a particular case of folds; it is, in fact, the structure which one would obtain by imagining a series of folds inclined in the same direction and by further supposing that in all these folds the half corresponding to the inverted beds had been suppressed. What makes the explanation difficult here is the fact that the movement is localized in the floors of the three stories, that is to say in bands of deposits of small thickness; one is at first led, under these conditions, to attribute it to the friction due to the masses which have been moved. It would be easy to suppose that these bands had been plicated by the shearing, as a cloth can be wrinkled by passing the hands over its surface, but it is less easy to conceive how these folds have been replaced by half-folds, or more exactly how the plication can have been replaced by a breaking up into fragments accompanied by a uniform uptilting of the successive fragments.

Without for the present seeking for the meaning and cause of each of these complications, a common character becomes distinguishable: folds are absent or exist only in a concealed form. At least, those that are met with are local accidents which can scarcely be appealed to in explaining the whole of the phenomena. Schematically one can always refer any movement to a fold of which a portion has disappeared; but whereas in the Alps such a disappearance is always momentary and allows the complete fold to reappear at a short distance, in Scotland the disappearance of the inverted portions is constant and almost without exception. In the one case, the explanation by means of folds is the result of direct observation; in the other it is based on *a priori* reasoning. The difference may be expressed in yet another way: in the Alps the suppression of beds is almost always due to sliding parallel to the stratification, and I have attempted in a previous article[1] to explain that this was a natural consequence of the parallelism between the beds and the forces of compression. In Scotland there is the same parallelism and yet the slides, with the exception of the three great thrusts, are almost always oblique to the stratification of the deposits. For so complete a change there must certainly be a general and deep-seated cause. This cause cannot reasonably be sought for in the nature of the forces in action; it must therefore depend upon the resistances brought into play. A remarkable series of experiments by Mr. Cadell, partly carried out with the collaboration of Mr. Peach, is perhaps such as to throw some light upon the question.[2]

[1] Revue générale des Sciences, t. iii. p. 1.

[2] Trans. Royal Soc. Edinburgh, vol. xxxv. part ii. p. 337.

It was necessary to use substances capable of plication within certain limits, but incapable of supporting a greater strain without fracture; alternations of plaster of Paris and damp sand fulfilled this condition; moreover, deformation was allowed free play by not weighting by the addition of any foreign body the mass of compressed beds. This was to deviate appreciably from the natural conditions where the weight of the beds, owing to the magnitude of the masses in motion, plays a considerable part, whilst in the experiment this action is negligeable. On the other hand, if by these means structures are produced comparable with those of the Highlands, one may conclude that the causes of the peculiarities presented are connected with a diminished *plasticity*, due either to the nature of the beds, or rather to their diminished thickness. It is, indeed, admitted now, following Professor Heim, that the plasticity to which the folds of mountain beds testify is due, on the one hand, to the slowness of the movements, and, on the other, to the enormous weight with which the folded parts were charged. For solid bodies, with sufficient pressure, the distribution of this pressure becomes, as with liquids, equal in every direction; and then, even if the cohesive forces be overcome, the particles, energetically maintained from all sides, are incapable of any but very slight relative motion; the body is deformed progressively, and without breaking.

As a matter of fact, Mr. Cadell's experiments reproduced with surprising fidelity some of the singular sections described in Scotland, notably the superposed thrust planes, and the beds piled up over themselves. The starting point is always the formation of a fold; but the beds thus brought in relief, being no longer sustained laterally, break, and their fragments transgress one over the other; the fold remains visible in the depth, although its form has disappeared from the surface owing to this kind of breaking up into pieces. As regards the piling up, the experiments produce it only in the upper portion of the system, almost always above a thrust plane, and as an extreme case of the collapse of an arch. The friction exerted by an upper thrust plane therefore plays no part here, and one is led to think that it may have been so likewise in the natural phenomenon, or at least that the friction above has only intervened so far as to cause the piled up fragments to lie in the direction of the movement, and to dispose them more horizontally. In other words, the slices of piled up beds would represent slices which have advanced further than that which is above them, and not so far as that which is beneath; and which, moreover, because of their small thickness, have undergone in a greater measure the retarding or accelerating action of the masses between which they lay. In this form, it will be at once perceived that the formula can be generalized, and gives in a very simple manner the general explanation of the phenomena; the thrust masses have been split up into a series of horizontal slices which have moved independently of one another;[1] the thick masses in one piece, the others subject

[1] This is exactly the formula which I proposed two years ago, when pointing out

to the secondary influence of the neighbouring masses. Taken thus, this formula only differs from that by which I attempted before to summarize the Alpine movements in that, as regards the latter, the successive slices are precisely the beds themselves, the planes of division being the planes of stratification, and therefore almost indefinite in number. In Scotland, as in the Alps, the pressures at first would form an arch, then, as they became greater, the arch in the one case would be bent downwards, and in the other would break. Pressure continuing, sliding movements would take place, following the bedding in the reclining fold, and following the fractures in the broken one. The difference between the two regions would be due to a difference in plasticity, *i.e.* to a difference of weight or thickness in the masses compressed. It will be seen how well this explanation agrees with the theory,[1] according to which the thickness of the superficial rocks compressed in consequence of the cooling of the earth increases with time. The differences between the mountains of Scotland and the Alps would be *a question of time*. No doubt this is yet but a hypothetical consequence; it may be added, however, that it is further confirmed by a comparison with the Coal-measure range. This chain, so well studied by Prof. Gosselet in the Ardenne, presents, on the borders of the coal-field, an intermediate structure, the part played by faults being there more accentuated than in the Alps, and less so than in Scotland. In any case, I cannot share Mr. Cadell's opinion when he says that in examining the Alps by the light of the new facts recognized in the Highlands, and confirmed by laboratory experiments, the same structures will be found there. It is not the observers who are at fault, it is the mountains which are not the same.

III. Side by side with the study of the movements themselves must be noted that of the metamorphism due to them. Nowhere, perhaps, outside the works of Reusch, in Norway, have clearer or more instructive examples been described. In the conglomerates, pebbles are seen to lengthen in the direction of the movement, sericite is developed in the quartzites, transforming them into micaceous schists traversed by little felspathic veins ("veins of pegmatite"). All these effects go on increasing as one approaches the east, and beneath the last great thrust plane we were enabled to see a remarkable section where, by reason of the repetition of the beds, one can follow almost step by step the progress of transformation, to a point at which the beds altogether cease to be recognizable, and can no longer be distinguished from the mass of crystalline schists ("Moine Schists") which surmount them.

At other points, on the contrary, where the upper "story" (in consequence of a lesser degree of denudation) advances further to the west, the separation of the two systems is clear and distinct; there is then found at the base of the crystalline schists a veritable

that the Scottish sections exhibited the material realization of this theoretical idea. Comptes Rendus Acad. Sci. 29th December, 1890, Report of M. Daubrée on the "Vaillant" prize.

[1] Davison and Darwin, Phil. Trans. Roy. Soc. 1887, p. 281.

friction breccia several metres thick in which the broken fragments are visible to the naked eye, but which is divided into parallel layers and appears stratified. The bedding is here evidently mechanical; it is a cleavage of the broken mass. For Mr. Peach the phenomenon is the same when the fragments cease to be visible and when they melt into an entirely crystalline paste. Everything then, the texture of the rock, as well as the appearance of sedimentation or its crystalline structure, would be the result of mechanical action, and that over an area of some thousands of square kilometres. It would even not be necessary to regard this enormous mass of schists as corresponding to any particular stage; the materials of which it consists would be furnished pell-mell by the rocks and deposits anterior to the movements. Here the hypothesis becomes somewhat too colossal to enable one to associate oneself with it. It seems to me difficult not to see in these crystalline schists as a whole, one special formation of definite age, which if not yet determined is certainly anterior to the Cambrian, a true stage (*étage*) in the ordinary acceptation of the term, and more or less to be likened to the micaceous schists and slates (*phyllades*) which in France form the top of the crystallophyllian series. It may be admitted that the apparent thickness of this group is augmented by a series of thrust planes and by the mechanical piling up already described; it may also be admitted that the visible bedding is cleavage. But in the absence of new arguments one can scarcely go further; the still recognizable patches of ancient gneisses or of Silurian beds found within the mass, must be considered as more ancient or more recent parts brought in by folds or by faults; but they cannot bear out the conclusion that the whole mass was formed of the same materials. As to the sudden appearance of a thick sedimentary series entirely wanting a few kilometres to the west, it reminds one exactly of what takes place in the Alps in the zone between the *massifs* of Mont Blanc and Monte Rosa. It would even be possible to follow, member by member, a curious correspondence in position between the series of the two regions: the gneisses of the Mont Blanc chain would tally with those of the Scottish coast; on these gneisses rest unconformably on the one hand the Carboniferous deposits, on the other the Torridon Sandstones of which I shall speak presently; the quartzites and limestones of the Trias take the place of the Cambrian quartzites and limestones of Scotland, and, east of the last named, instead of seeing a reappearance of the older divisions over which they lie to the west, we encounter only an immense succession of schists unknown on the other side, the *Moine schists* in Scotland and the lustrous schists in the Alps. In these last, moreover, patches of Trias are found intercalated, as shreds of Cambrian are enclosed in the schists of Scotland.

This is, however, not the place to insist upon these *Moine Schists*, the question which of all others remains the most obscure, and on which next to nothing has been published. The last observations I wish to mention in concluding are those relating to the gneiss rocks of the coast. There the post-Cambrian movements are no longer felt; the prodigiously dislocated region which we have been

studying is succeeded by another where reigns the appearance of the most complete calm, where the gneisses themselves are but feebly and gently undulated, where the sandstones which overlie them have almost everywhere remained horizontal. These sandstones (Torridon Sandstone), of which I have already said one word, recall the aspect of our Permian stage by their coarsely detrital nature and by their red and brown colour; in their entire thickness, which is great, there is no trace of metamorphism. They are, however, incontestably older than the Cambrian quartzites everywhere to be seen resting unconformably with a slight dip to the east on the slices of the obliquely cut horizontal sandstones. Erosion has deeply sculptured these sandstones into isolated peaks of quaint and abrupt shapes, like immense fortresses guarding the coast-line; strangers, as MacCulloch said—the first geologist who described them—by their nature and by their structure to all that surrounds them, they seem astonished to find themselves where they are. Their horizontality, their freshness, their resemblance to more recent deposits, these are so many indications that the basement on which they rest has itself remained much as it was in those ancient times. What can be studied at their base then are the gneisses such as they were before the Cambrian epoch.

This is a point of great importance; it is owing to circumstances of this kind that the study of the gneisses will always be easier and more fruitful in more northern countries than in ours. Where the Earth's crust has been dislocated up to more recent times, the gneisses are only exhibited to us with all the transformations due to metamorphism and to the successive injection of igneous rocks. It does not appear that this complexity has given rise to special types (though I do not think that a serious study, without preconceived views, has yet been carried out in this direction); but at any rate such a complexity renders it more difficult to assign to each agent the part it may have played. Where on the contrary, as in Scotland, deformation has stopped at its first stage, the problem is simplified, and the chances are greater that precise conclusions may be arrived at.

The gneisses of the Scottish coast are basic gneisses, in which the mica is replaced by amphibole or pyroxene; they are granitoid gneisses, *i.e.* the arrangement of the dark-coloured materials along parallel lines is but faintly indicated in them. They are traversed by numerous basic veins, from diabases to peridotites, and all anterior to the Torridon Sandstone. These gneisses, as I have said, constituted the platform against which the tremendous flood of the Silurian displacements stopped without shaking it; but in it are found traces of more ancient movements, later than the basic veins, and prior to the Torridon Sandstone. These movements it has been possible to study in detail, and they have yielded precious data.

They are narrowly localised along lines or bands of small breadth, compared by Mr. Peach to vertical thrust planes; along these lines, which sometimes follow the veins, the latter are transformed into hornblende schists, with a little mica and lenses of dioritic matter; the peridotites pass into talcose schists. In the gneisses there is mica formed in lines along the direction of the movement; the new

planes of orientation are independent of the primitive foliation, which they cut across, and sometimes obliterate completely, and all the stages of the changes can be followed. It will be seen, since the original foliation here plays no part, that the result would have been the same in a granite; one is assisting, in fact, *at the formation of gneiss, and of amphibolic schists, by means of the foliation of granitoid rocks.* This theory has already been several times proposed, and has been cited in support of other observed facts; but I do not think that any of these facts can present themselves more clearly or offer an easier verification than those under consideration.

It may be objected that the effect is produced in narrow areas only; but it is so by a phenomenon which is only exceptionally localised, and which, from what is known of its other effects, is capable of extension over masses of almost indefinite size. One is thus in a position to conclude that the foliation of eruptive rocks is one of the possible and even probable modes of formation of gneiss. In the first place, as has been seen already, the same mechanical metamorphism may be applied to sedimentary rocks. Moreover, M. Michel Lévy has proved that the injection of eruptive into sedimentary rocks can equally produce true gneisses: perhaps only in this case is it less easy to conceive of the extension of the phenomenon to vast areas. Lastly, there may be gneisses formed originally and directly in the state of gneiss, corresponding in such a case to the first crust of the solidified globe. Dr. A. C. Lawson has described an interesting example of this in Canada, which would approximate this mode of formation to that of the eruptive rocks. Here are, then, three possible origins, outside all theory, and it must be owned that choice, in the present state of knowledge, is very seldom possible for each particular case. The observations of Messrs. Peach and Horne mark, however, a further step towards the solution, and what L. von Buch said of the Tyrol may be repeated here. All geologists who take up these questions should make a pilgrimage to the Scottish coast.

In concluding this summary, it remains to me to express the desire that these beautiful discoveries may be, as soon as possible, published in all their details. The Report of 1888 is but a *résumé* of the most important facts; one has a right to expect, and to demand, a complete monograph. All the elements of such a monograph will soon be gathered together; they must be made public. It is desirable that a micrographic study should accompany and give precision to all the observations relating to metamorphism, and especially that it may be possible to follow the perusal of the Memoir on detailed maps. An immense amount of labour has been undergone in carrying out this survey: the reduction to a scale one-sixth of that of the original maps will cause an almost inextricable complication of lines, and the loss of the benefit of part of the work. The region presents an interest sufficiently exceptional, and sufficiently general, to raise it above the rules of ordinary routine, and the question of cost is not an obstacle. England is rich enough to pay for its glory.

II.—On a Meteoric Stone found at Makariwa, near Invercargill, New Zealand. By G. H. F. Ulrich, F.G.S., Prof. of Mining and Mineralogy in the University of Dunedin, New Zealand. (Proc. Royal Society, London, 1893.)

THE specimen described in this Memoir was found in the year 1879, in a bed of clay, which was cut through in making a railway at Invercargill, near the southern end of the Middle Island of New Zealand. Originally this meteorite appears to have been about the size of a man's fist, and to have weighed 4 or 5 lbs., but it was broken up, and only a few small fragments have been preserved. The stone evidently consisted originally of an intimate admixture of metallic matter (nickel iron) and of stony material, but much of the metallic portion has undergone oxidation. Microscopic examination of thin sections shows that the stony portion, which is beautifully chondritic in structure, contains olivine, enstatite, a glass, and probably also magnetite, and through these stony materials the nickel iron and troilite are distributed. The specific gravity of portions of the stone was found to vary between 3·31 and 3·54, owing to the unequal distribution of the metallic particles. A partial chemical examination of this meteorite was made by the author and Mr. James Allen, but the complete analysis has been undertaken by Mr. L. Fletcher, F.R.S., of the British Museum. The analysis, which, when finished, will be communicated to the Royal Society, has gone so far as to show that the percentage mineral composition of the Makariwa meteorite may be expressed approximately by the following numbers; nickel iron 1, oxides of nickel and iron 10, troilite 6, enstatite 39, olivine 44.

REVIEWS.

I.—An Introduction to the Study of the Genera of Palæozoic Brachiopoda. Part I. By James Hall, assisted by John M. Clarke. Geological Survey of the State of New York. Palæontology. Vol. VIII. 1892. Large 8vo. pp. xvi. 367, with 43 Plates.

IN many valuable volumes Professor Hall has described the Palæozoic fossils of the State of New York. In the long series of years during which he has been labouring in his appointed field, progress has necessarily been made in other lands and by other workers. Consequently, work that was admirable twenty years ago runs some risk of being overlooked at the present day unless it is brought into line with recent discoveries. To summarise and consolidate the knowledge of the past enables us to appreciate better both the perfections and imperfections of our science, and affords the surest ground for further progress. This is the task that is now being attempted for Palæozoic Brachiopoda by Messrs. Hall and Clarke, and the first-fruits of their toil are seen in the volume before us.

The plan of this work is to describe very completely each genus

and sub-genus, comparing it with allied genera and referring to it the more important species both of America and Europe. At the same time a good bibliography is given of each genus, and every attempt made to ensure that it shall receive the name by which its first author intended that it should be known. So far as the work is at present carried, it deals with the genera usually classed as Inarticulata or Tretenterata, and with those genera of the Articulata that may naturally be grouped around *Orthis*, *Leptæna*, *Chonetes*, and *Productus*. The second part, which we are glad to learn is already far advanced, will deal with the spire-bearing and terebratuloid forms. No attempt is made to group the genera in families, for the authors consider that such a classification would be "arbitrary and procrustean, and would only be embarrassing to the student without any corresponding benefit." The relationships of the genera are, however, treated of in separate chapters.

The casual reader of this work will note, perhaps with dismay, a very large number of new generic names. The authors, indeed, confess that they have used "as many terms of this value as are in any way justifiable." They assure us, however, that the future will prove some of these generic groups to be still too broad; and no student of the recent progress of systematic zoology can venture to contradict them. Such new terms are: *Barroisella* (type, *Lingula subspatulata*, M. & W.); *Tomasina* (type, *Lingula Criei*, Dav.); *Discinopsis* (type, *Acrotreta*? *Gulielmi*, Matthew); *Œhlertella* (type, *Discina pleurites*, Meek); *Lindstroemella* (type, *L. aspidium*, n. sp.); *Rœmerella* (type, *Discina grandis*, Vanuxem); *Plectorthis* (type, *Orthis plicatella*, Hall); *Dinorthis* (type, *Orthis pectinella*, Emmons); *Plæsiomys* (type, *Orthis subquadrata*, Hall); *Hebertella* (type, *Orthis sinuata*, Hall); *Heterorthis* (type, *Orthis Clytie*, Hall); *Dalmanella* (type, *Orthis testudinaria*, Dalman); *Orthotichia* (type, *Orthis*? *Morganiana*, Derby); *Billingsella* (type, *Orthis Pepina*, Hall); *Protorthis* (type, *Orthis Billingsi*, Hartt); *Polytæchia* (type, *Hemipronites apicalis*, Whitf.); *Orthidium* (type, *Orthis gemmicula*, Bill.); *Kayserella* (type, *Orthis lepida*, Schnur); *Rafinesquina* (type, *Leptæna alternata*, Conrad); *Leptella* (type, *Leptæna sordida*, Bill.); *Christiania* (type, *Leptæna subquadrata*, Hall); *Chonostrophia* (type, *Chonetes reversa*, Whitf.); *Chonopectus* (type, *Chonetes Fischeri*, Norw. and Pratt.). After this it is reassuring to find that certain old and well-known names have not entirely disappeared, although the sense in which they are retained is rather different from that attributed to them of recent years. Thus, *Orthis* proper is here restricted to a small group of species of which *Orthis callactis* is the type; *Strophomena* is at last applied to the species for which Rafinesque originally intended it, viz. *Leptæna planumbona*, Hall, while *Leptæna* naturally returns to the well-known species that for the first thirty years of its existence was acknowledged as its type, the *Conchites rhomboidalis* of Wilckens or *Producta rugosa* of Hisinger, a fossil that has for many years usurped the title of *Strophomena*. It will be noticed that these changes, and others that might be mentioned, such as the restitution of *Clitambonites*, Pander, to the place from

which it was ousted by D'Orbigny's *Orthisina*, are no resuscitation of "rusty rubbish," but are simply a return to names that were actually used by scientific writers until, through ignorance or impudence, other names were substituted for them. Those critics who raise such an outcry over changes of nomenclature would often find, if only they would take the trouble to look into matters, that the names they take upon themselves to defend are but modern upstarts after all. In considering a question so vast and so far-reaching as this of nomenclature, we must take into account not merely our own short lives, nor even the poor hundred years that comprise the history of systematic zoology, but the centuries that are to come and the posterity for whom, if for anyone, we ourselves are working. The student of 2093, should he have occasion to consider the literary history of the name *Leptæna*, will regard the thirty years of its application to *Plectambonites transversalis* as nothing more than a temporary aberration.

It would be impossible to indicate in these pages half the interesting deductions of the authors, deductions that derive very great importance from the extended nature of the facts and philosophical character of the arguments on which they are based. A slight sketch of some of their results with regard to the Inarticulata will, however, serve as an example of their method.

Hitherto the muscle-scars have been taken as features of supreme classificatory importance, but the uncertainty and frequent obscurity of these characters lead the authors to subject them to the nature of the pedicle-passage, a point in which they agree with Dr. C. E. Beecher. In its early stages of shell-growth, *Lingula* recalls the features of obolelloid shells, a type that culminated before *Lingula* appeared on the scene; while *Lingulella* and *Lingulepis*, which precede *Lingula*, are actual links in which the shape of *Lingula* is combined with the narrow pedicle-slit and simple muscle-arrangement of the obolelloids. Our authors favour the opinion, which was beginning to lose ground, that *Lingula* has persisted from the Silurian to the present day; numerous branches, however, have been given off by the way. Thus, an increased secretion of shelly substance, or stereom, about the insertions of the muscular and parietal bands produced the median and lateral septa that characterize *Dignomia* and the more recent *Glottidia*. *Obolella* is another important genus from which other forms may be traced. In one direction, as just mentioned, it is connected with *Lingula* by way of *Lingulella*. Similar specialization of muscles, combined however with retention of the circular form, leads to *Obolus*, whence arise in different directions *Leptobolus*, *Schmidtia*, *Paterula* and *Schizobolus*.

It has of late been forcibly impressed on us that the same structure may appear along different lines of development, and to this the Brachiopoda are no exception. On *a priori* grounds one would hardly be prepared to admit that the two divisions, Articulata and Inarticulata, represent divergent branches; one would rather imagine that the Articulata must have been derived from the Inarticulata at numerous points. We now know that in many

respects the more highly organised of the Inarticulata do approach the Articulata. To consider only one character, the formation of a hinge: in *Barroisella*, a descendant of *Lingula*, the deltidial callosities are developed to such a degree as to indicate their specialization for purposes of articulation; in *Spondylobolus* a similar result appears to have been arrived at by way of *Obolella*. *Trimerella* and *Monomerella* similarly tend to develop articular processes in their pedicle-valve, while *Neobolus* has a strong cardinal process in its branchial valve. It does not, however, appear that as yet any distinct connection can be established between articulate and inarticulate genera.

Another structure arrived at along two distinct lines is the platform of the so-called Trimerellidæ, a family that, if the authors' conclusions are correct, can of course no longer be maintained. This platform has been evolved by the raising of the anterior edges of the stereom at the bases of the central and lateral muscles, a raising which the authors suggest is due to displacement of, and pressure against, the liver; this has induced a thickening of the entire area of muscle-attachment, and the solid plate so formed has been gradually excavated and changed into a more or less vaulted platform. The authors show that this evolution has proceeded from *Lingula* through *Lingulops* and *Lingulasma* to *Trimerella*, and again from *Obolus* through *Elkania* to *Dinobolus*. It is remarkable that both these lines should have culminated at the close of the Silurian period, both in the Guelph Limestones of Canada and in the uppermost beds of Gotland; but we would ascribe this to the natural working of the laws of growth rather than to any specially favourable conditions of the later Silurian sea.

Into their further investigations we forbear to follow these authors; this, however, is the less to be deplored, since a perusal of their work is not only absolutely necessary for the student of the Brachiopoda, but should prove both pleasant and instructive to all naturalists. For the book is written in a clear and interesting manner,—not too greatly marred by such phrases as "a series eventuates," "the edentulous brachiopods," "features approach desuetude" and "to fortify a view," and entirely free from the horrible jargon of "naepionic," "clinologic," "ephebolic" and the rest, that renders almost unintelligible some of the most valuable and suggestive American work; and there are besides 43 plates filled with figures most appropriately selected by the authors and admirably rendered by the artists.

The large list of those in the United States, Canada, and the different countries of Europe, to whom Prof. Hall acknowledges his indebtedness, is a pleasing instance of that "federation of the world" in which scientific men are far ahead of politicians; and the bibliographic tables supplied by Mr. Charles Schuchert show that, at least to students of the Brachiopoda, the walls of Babel prove no hindrance.

F. A. Bather.

II.—Annals of British Geology, 1891. A Digest of the Books and Papers published during the year; with Occasional Notes. By J. F. Blake, M.A., F.G.S., etc. 8vo. pp. x.–434; 6 Plates. (London: Dulau & Co., 1892.)

WE welcome with much pleasure the second issue of this extremely useful work of reference, which deserves the support of all British geologists. It contains the titles and abstracts of 650 papers, or 90 more than that of last year. These are arranged under the headings of: General Geology; Stratigraphical Geology; Palæontology; Mineralogy; Petrology; Economics; Maps and Sections; Foreign Geology (published in Britain); Misplaced; Supplement for 1890. The section next to the last is "misplaced" as to its heading rather than as to its matter, and would more correctly have been styled "addenda." The most important addition to the present volume is that of the plates. Of these two are maps, the others reproductions of the illustrations of new fossils, etc.; but we fail to see how these can be maintained as a feature in such a record.

It is satisfactory to note that the remarks of the compiler, which in the previous year were intercalated between [ ] in the text, and which gave rise to some sharp discussions, are this year confined to notes, and fortunately fewer in number, though even now capable of further reduction. It is hardly necessary to take up a line of foot-note to call attention to an obvious misprint of a 3 for an 8 (p. 50); nor do such notes as that on p. 57 help anybody. The wise recorder obtrudes his personality as little as possible.

The patience and industry shown in reproducing lists of fossils is most praiseworthy; but one can have too much of a good thing, and where a work practically consists entirely of such, it is hardly worth while to reproduce it, as in one instance, which covers nine pages of these annals, even when the 585 worthless MS. names of the original are omitted.

Space might with advantage, too, be gained in future by omitting the section "Foreign Geology (published in Britain)," which necessarily being but the fragment of a larger record is valueless, because incomplete, and lies moreover without the scope of "British Geology."

It is a great pity that in the case of works of this sort their value really begins only when a number of years have been completed; one or two volumes alone are practically of little moment. Under these circumstances all the more credit attaches to the individual who, single-handed, has the pluck to undertake so risky a venture, and that at a time when Geological Records in this country, at all events, are not in particularly high favour.

We trust that the means will be forthcoming to enable Professor Blake to continue a work so well begun, for, as he warns us in his preface, "the series can only be continued beyond a third volume if it be made, at least, self-supporting." Geologists as a body are not wealthy, but are, nevertheless, ever ready to contribute individually their mite to a good cause; whilst, as to the wealthy few, *verb. sap. suff.*

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—January 25th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On Inclusions of Tertiary Granite in the Gabbro of the Cuilin Hills, Skye; and on the Products resulting from the Partial Fusion of the Acid by the Basic Rock." By Prof. J. W. Judd, F.R.S., V.P.G.S.

The author first calls attention to previous literature bearing on the subject of the extreme metamorphism of fragments of one igneous rock which have been caught up and enveloped in the products of a later eruption. The observations of Fischer, Lehmann, Phillips, Werveke, Sandberger, Lacroix, Hussak, Graeff, Bonney, Sauer, and others show that, while the porphyritic crystals of such altered rocks exhibit characteristic modifications, the fused ground-mass may have developed in it striking spherulitic structures.

On the north-east side of Loch Coruiskh, in Skye, there may be seen on a ridge known as Druim-an-Eidhne, which rises to a little over 1000 feet above the sea, a very interesting junction of the granitic rocks of the Red Mountains with the gabbros of the Cuilin Hills. At this place, inclusions of the granitic rock, sometimes having an area of several square yards, are found to be completely enveloped in the mass of gabbro. The basic rock here exhibits all its ordinary characters, being a gabbro passing into a norite, traversed by numerous segregation veins; the acid rock is an augite-granite, exhibiting the micropegmatitic ("granophyric") and the drusy ("miarolitic") structures, and it passes in places into an ordinary quartz-felsite ("quartz-porphyry").

Within the inclusions, however, the acid rock is seen to have undergone great alteration from partial fusion, and it has acquired the compact texture and splintery fracture of a rhyolite; weathered surfaces of this rock are found to exhibit the most remarkable banded and spherulitic structures.

Microscopic study of the rock of these inclusions shows that the phenocrysts of quartz and felspar remain intact, but exhibit all the well-known effects of the action of a molten glassy magma upon them. The pyroxene, however, has been more profoundly affected, and has broken up into magnetite and other secondary minerals. The micropegmatitic ground-mass, which was the last portion of the rock to consolidate, has for the most part been completely fused, and in some places has actually flowed. In the glassy mass thus formed, the most beautiful spherulitic growths have been developed, the individual spherulites varying in size from a pin's head to a small orange. These spherulites are often composite in character, consisting of minute examples of the common type enclosed in larger arborescent growths ("porous-spherulites") of felspar microlites, with silica, originally in the form of opal and tridymite, but now converted into quartz, lying between them. All the interesting forms of spherulitic growth which have been so well described by

Mr. Iddings from the Obsidian Cliff in the Yellowstone Park, and by Mr. Whitman Cross from the Silver Cliff, Colorado, are most admirably illustrated in these inclusions of the Cuilin Hills. It is interesting to note that the nuclei of some of these large spherulites consist of fragments of the micropegmatitic granite which have escaped fusion. Among the new minerals developed in these inclusions, by the action on them of the enveloping magma, are pyrites and fayalite (the iron-olivine).

The phenomena now described are of interest as setting at rest all doubts as to the order of eruption of the several igneous masses of the Western Isles of Scotland. That the gabbros are younger than the granites was maintained by Macculloch in 1819, by J. D. Forbes in 1846, by Zirkel in 1871, and by the author in 1874. In 1888, however, Sir A. Geikie asserted that these conclusions were erroneous; he insisted that the granites were erupted *after* the gabbros and basalts, and that they are, indeed, later than all the volcanic rocks of the district except a few basic dykes which are seen to traverse them. The occurrence of the remarkable inclusions of granite within the gabbro now removes all possibility of doubt on the subject, and proves conclusively that the granite was not only erupted but had consolidated in its present form before the outburst through it of the gabbro.

2. "Anthracite and Bituminous Coal-beds. An attempt to throw some light upon the manner in which Anthracite was formed; or contributions towards the controversy regarding the Formation of Anthracite." By W. S. Gresley, F.G.S.

The author does not seek to advance any new theory in this communication, nor to proclaim new facts of any importance, but to put old facts in something of a new light, in order to aid the investigations of others. His main object is to establish two facts, viz.:—that the associated strata of anthracite-beds are more arenaceous than those containing so-called bituminous coal-beds, and that the prevailing colours of the sandstones, grits, etc., of anthracite regions are greyer and darker than those of regions of bituminous coal. To these facts may perhaps be added a third, that the more anthracitic the coal-beds, and the more siliceous the enclosing strata, the harder and tougher these associated strata are.

While recognizing that the rocks of many anthracite regions have undergone great disturbance, he cites other areas where coal-basins have been much folded, without any corresponding production of anthracite in considerable quantity.

The modes of occurrence of anthracite are illustrated by many instances observed by the author in the Old and New Worlds.

II.—February 8th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:

1. "Notes on some Coast-Sections at the Lizard." By Howard Fox, Esq., F.G.S., and J. J. H. Teall, Esq., M.A., F.R.S., F.G.S.

In the first part of the paper the authors describe a small portion of the west coast near Ogo Dour, where hornblende-schist and serpentine are exposed. As a result of the detailed mapping of the

sloping face of the cliff, coupled with a microscopic examination of the rocks, they have arrived at the conclusion that the serpentine is part and parcel of the foliated series to which the hornblende-schists belong, and that the apparent evidences of intrusion of serpentine into schist in that district are consequences of the folding and faulting to which the rocks have been subjected since the banding was produced. The interlamination of serpentine and schist is described. and also the effects of folding and faulting. Basic dykes, cutting both serpentine and schists, are clearly represented in the portion of the coast which has been mapped, and these locally pass into hornblende-schists, which can, however, be clearly distinguished from the schists of the country. The origin of the foliation in the dykes is discussed.

The second part of the paper deals with a small portion of the coast east of the Lion Rock, Kynance. Here a small portion of the "granulitic series" is seen in juxtaposition with serpentine. The phenomena appear to indicate that the granulitic complex was intruded into the serpentine; but they may possibly be due to the fact that the two sets of rocks have been folded together while the granulitic complex was in a plastic condition, or to the intrusion of the serpentine into the complex while the latter was plastic.

2. "On a Radiolarian Chert from Mullion Island." By Howard Fox, Esq., F.G.S., and J. J. H. Teall, Esq., M.A., F.R.S., F.G.S.

The main mass of Mullion Island is composed of a fine-grained "greenstone," which shows a peculiar globular or ellipsoidal structure, due to the presence of numerous curvilinear joints. Flat surfaces of this rock, such as are exposed in many places at the base of the cliff, remind one somewhat of the appearance of a lava of the "pahoehoe" type.

The stratified rocks, which form only a very small portion of the island, consist of cherts, shales, and limestone. They occur as thin strips or sheets, and sometimes as detached lenticles within the igneous mass. The chert occurs in bands varying from a quarter of an inch to several inches in thickness, and is of radiolarian origin. The radiolaria are often clearly recognizable on the weathered surfaces of some of the beds, and the reticulated nature of the test may be observed by simply placing a portion of the weathered surface under the microscope.

The authors describe the relations between the sedimentary and igneous rocks, and suggest that the peculiar phenomena may be due either to the injection of igneous material between the layers of the stratified series near the surface of the sea-bed while deposition was going on, or possibly to the flow of a submarine lava.

The forms of the radiolaria observed in the deposit, and also their mode of preservation, are described in an Appendix by Dr. G. J. Hinde.

3. "Note on a Radiolarian Rock from Fanny Bay, Port Darwin, Australia." By G. J. Hinde, Ph.D., V.P.G.S.

A specimen brought from Fanny Bay by Captain Moore, of H.M.S. "Penguin," is of a dull white or yellowish tint, in places stained red. It has an earthy aspect, and is somewhat harder than

chalk, but gives no action with hydrochloric acid. Microscopic sections show a fairly transparent ground-mass, apparently amorphous silica, containing granules and subangular fragments up to ·075 millim. in diameter, some of which appear to be quartz.

Besides this, the rock contains numerous radiolaria, and it is really a radiolarian earth intermediate in character between the Barbados earth and such cherts as those of the Ordovician strata of Southern Scotland.

The details of the extent of the deposit and its relationship to other rocks of the area are not yet obtainable, though it is possible that a considerable thickness of rock mentioned by Mr. Tenison Woods as occurring in this area may also be of radiolarian origin.

The author describes a species of *Cenellipsis*, two of *Astrophacus*, one of *Lithocyclia* (new), one of *Amphibrachium*, three of *Spongodiscus* (one new), four of *Spongolena* (all new), two of *Dictyomitra* (both new), one of *Lithocampe* (new), and two of *Stichocapsa* (both new).

From these it is not practicable at present to determine the geological horizon of the rock; with one exception, all the genera represented occur from Palæozoic times to the present.

4. "Notes on the Geology of the District west of Caermarthen." Compiled from the Notes of the late T. Roberts, Esq., M.A., F.G.S. (Communicated by Prof. T. McKenny Hughes, M.A., F.R.S., F.G.S.)

To the east of the district around Haverfordwest, formerly described by the author and another, an anticlinal is found extending towards Caermarthen. The lowest beds discovered in this anticline are the *Tetragraptus*-beds of Arenig age, which have not hitherto been detected south of the St. David's area. They have yielded eight forms of graptolite, which have been determined by Prof. Lapworth. The higher beds correspond with those previously noticed in the district to the west; they are, in ascending order: (1) Beds with "tuning-fork" *Didymograpti*, (2) Llandeilo limestone, (3) *Dicranograptus*-shales, (4) Robeston Wathen and Sholeshook Limestones.

Details of the geographical distribution of these and of their lithological and palæontological characters are given in the paper.

Glasgow Geological Society, Dec. 8.—Mr. Dugald Bell, F.G.S., read a paper "On the Origin of certain Granite Boulders in the Clyde Valley." He referred to the opinion expressed by the late Mr. Smith of Jordanhill, many years ago, that a number of these boulders around Glasgow had been derived from the neighbourhood of Ben Cruachan. With all respect to so eminent an authority, this seemed impossible, as according to the evidences of glaciation in the intervening district, such boulders would have to traverse at least two great sheets of land-ice moving in quite a different direction, viz. southward and south-westward, instead of eastward as required. Besides, the granite of the boulders referred to is strikingly different from the Ben Cruachan granites. Judging from the ice-marks, he (Mr. Bell) had long thought that the locality in which these boulders originated was to be found in the mountainous tract between the head of Lochlomond and the head of Lochfyne. More than thirty

years ago the late Prof. James Nicol, of Aberdeen, in his "Geological Map of Scotland," had indicated two limited areas of granite in that region, but the later maps of Murchison (1861) and Geikie (1874) contained no such indications. On a recent visit to St. Catherine's, opposite Inveraray, he had been struck by the enormous number of granite boulders, quite resembling those under notice, which lay strewn at that point along the eastern shore of Lochfyne, and it seemed impossible that these could have come across the loch, all the evidences of glaciation being strongly southward. He had, therefore, been convinced that the parent locality of these boulders was not far distant, probably in the upper part of Glenfyne. Though he had not as yet found leisure to make a personal exploration, he thought the conclusions he had arrived at were confirmed, indeed proved by the officers of the Geological Survey, who had lately described a granitic tract of about ten square miles on the eastern side of the northern part of Glenfyne, extending to, and slightly beyond, the water-shed between it and Glen Falloch. He further pointed out how from this locality, by Loch Eck and the Holy Loch, by Loch Long, and partly by Lochlomond, land-ice bearing the boulders in question could have reached the various points at which they had been found. At the close of the paper some discussion took place, the speakers generally agreeing with Mr. Bell in the conclusion at which he had arrived.

CORRESPONDENCE.

THE MAMMOTH AND THE GLACIAL DRIFT.

Sir,—I shall feel obliged if you will allow me to amend the sentence "Mammoth from the Lower Glacial Gravel at Finchley" in my letter in the last Number of the Geological Magazine, by substituting *Elephas* for Mammoth as being more correct, as the specimens are not such as would enable us to identify the species. In the other cases cited the bones were undoubtedly those of the Mammoth.

Henry Hicks.

Hendon, *Feb.* 10, 1893.

THE ROCKS OF SOUTH DEVON.

Sir,—The issues raised by Professor Bonney's recent letters on the South Devon Rocks are so important and multifarious, that to deal with them adequately would require a far longer article than the limits of the Magazine could admit. For instance, without going further, I find in my copy of the Professor's original Devon paper (Q.J.G.S. vol. xl.), no less than 113 separate points noted and numbered for comment and criticism.

I hope on some future occasion to find both time and opportunity for a careful analysis and collation of several of Professor Bonney's papers, with especial reference to his position with regard to the Devonshire schists. In the meantime I venture to deprecate the

constant introduction, by so distinguished a petrologist, of personalities, which are quite unworthy of a man of science, which are sure to revert upon himself, and which may even reflect indirectly on the British School of Petrology, of which for so many years Professor Bonney has been a prominent exponent.

SOUTHWOOD, TORQUAY, 18*th February*, 1893. A. R. HUNT.

SCANDINAVIAN ROCKS IN THE ENGLISH BOULDER-CLAYS.

SIR,—In connection with the subject raised by Herr Madsen's recently published paper on "Scandinavian Boulders at Cromer,"[1] it may be of interest to give a list, brought up to date, of the Norwegian rocks which I have examined from the Boulder-clays of Holderness.

(i). Augite-syenite ('laurvikite' of Brögger) from the neighbourhood of Laurvig.

(ii). 'Rhombenporphyr' of Kjerulf and others, from the Christiania district.

(iii). 'Saussurite-gabbro,' as described by Möhl and Reusch from the west coast of Norway; two or three varieties.

(iv). A rather coarse red granite with much microcline and microperthite and subordinate dark mica. This agrees well with the rock described by Brögger from the Christiana district, but I have no specimens for comparison.

(v). Various grey granites with dark or with both dark and white micas, corresponding to those largely developed in the 'Grundfjeld' of Norway. These, unlike the preceding, always show cataclastic structures, strained quartz, etc.

(vi). Well-banded gneisses, the coarser ones hornblendic, the finer micaceous.

(vii). Various hornblende-schists and mica-schists, the latter often garnetiferous. These and the gneisses it would be impossible to refer to precise localities, but their Scandinavian origin cannot be doubted. ALFRED HARKER.

ST. JOHN'S COLLEGE, CAMBRIDGE.

SIR,—There is a curious error, which by some oversight has crept into my letter in the February Number of this MAGAZINE. The sentence—"Creditably again is so variable a factor," etc. (which makes nonsense) should read "Credibility," as it stands in the rough MS. which I have by me. Most readers of the GEOL. MAG. have probably made the correction fer themselves. A. IRVING.

WELLINGTON COLLEGE, BERKS, 4 *Feb.* 1893.

TITLES OF SEPARATE COPIES OF SCIENTIFIC PAPERS.

SIR,—A few years ago I advocated in your pages a reform in regard to the titles of separate copies of scientific papers: its adoption encourages me to venture further suggestions on the same lines in regard to the volumes themselves. My suggestions are:—

[1] Q.J.G.S. vol. xlix. p. 114, 1893.

that all papers should begin on a separate page; and that they should bear, as a heading, the full title of the publication in which they appear. My object is to facilitate work. I venture to say that it is a saving of time and temper for anyone, whether specialist or not, to have all their literature on any particular subject, or subdivision of a subject placed together: to attain this it is necessary to "break" publications, and to assort their papers. At present this too often entails the destruction of the preceding or succeeding paper—a matter for regret when only a limited number of copies is issued.

My suggestion would obviate this. I could wish it were applied to all publications in which original communications occur; but this, I fear, is Utopian. To the publications, however, of societies dealing with various sciences it is very necessary; to the publications of those dealing with one science it is quite as imperative, because subdivisions of a science are so numerous now. Very frequently the object desired could be attained by moving the first paper in the volume by one page; but in any case not one extra (blank) page per paper would be required. Expense, therefore, can hardly be urged against the proposal; while the boon conferred would be very great.

S. S. Buckman.

THE MAMMOTH AND THE GLACIAL DRIFT.

Sir,—I have no desire to prolong this unprofitable controversy and must decline further argument with Sir H. Howorth, who still imagines he has completely proved his case, and who imputes to me words which I never employed. He takes up your space with discussing "authority" as if I had used the term, whereas my phrase was "the generally accepted views of geologists," or in other words what Sir Henry himself calls "the orthodox geological opinion."

With Dr. Hicks the case is different; but I think he should have known me better than to imagine I had the slightest idea of posing as an "official" or "professional" geologist. I used the term "practical," and by a *practical geologist* I mean anyone who has had experience in the work of mapping geological boundaries and collecting evidence for the construction of profile sections. By "approved work in the field" I mean work which stands the test of investigation by other geologists. I think Dr. Hicks will agree with me that a man who merely visits some well known sections in a faulted Palæozoic district is not entitled to criticize accepted views of its structure. Similarly in studying areas of Drift deposits it is often impossible to say whether a given patch of gravel is above or beneath Boulder-clay from a mere inspection of open sections, though their relations may become clear when the area is carefully mapped.

Is Dr. Hicks prepared to say, as Sir H. Howorth does, that there is no good ground for supposing the Hoxne deposits to be underlain by the neighbouring Boulder-clay? and in the face of Mr. Reid's statement in this Magazine (1888, p. 442), does he consider the

superjacent patches of Boulder-clay to be in place? Unless he refuses credence to the observations of Messrs. Prestwich, H. B. Woodward, and C. Reid, he cannot support Sir H. Howorth.

I have confined myself to denying Sir Henry's contention that Mammoth-bearing deposits are "never underlain by Glacial Drift." I am perfectly prepared to admit that Mammoth-remains do occur under undoubted Glacial deposits, as Dr. Hicks maintains, but that is not the point in question. A. J. JUKES-BROWNE.

EXETER, *Feb.* 7, 1893.

A BORING AT WILLOUGHBY IN LINCOLNSHIRE.

SIR,—I think you will find that the boring at Willoughby, mentioned in the paragraph quoted from the "Morning Post" in the GEOLOGICAL MAGAZINE for February, was made in 1887. I have some particulars of the strata passed through which I hope to publish shortly, and will only now say that it supplies valuable information about the subterranean structure of that part of Lincolnshire. The boring passed directly from Glacial Drift into the so-called Neocomian, without the intervention of any kind of Chalk. Water was found at the top of the Spilsby Sandstone.

EXETER, *Feb.* 7. A. J. JUKES-BROWNE.

SUBTERRANEAN EROSION.

SIR,—In the GEOLOGICAL MAGAZINE for September, 1892, Mr. Morton, F.G.S., criticised a paper I read in December, 1891, before the Geological Society, entitled "The Subterranean Erosion of the Glacial Drift, a probable cause of Submerged Peat and Forest Beds" (Quart. Journ. Feb. 1892, pp. 96–103). So far as Mr. Morton's criticisms partake of the nature of a defence of his theory of the origin of the submerged Peat and Forest-beds of Lancashire and Cheshire as described in his work entitled "The Geology of the Country around Liverpool" I do not propose to discuss, for if Mr. Morton's theory be right then my theory must be wrong, and *vice versa.*

Mr. Morton's remarks, however, go beyond the mere local application of the principle of subterranean erosion. In concluding, he writes, "It is very remarkable that such an active agent has not been observed in Tertiary formations of the South of England where the beds of clay and sand are similar and occur under the same conditions." I go further even than Mr. Morton, viz.—If the principle of Subterranean Erosion be true at all it will prove as true in the past as in the present (under the conditions mentioned) and as wide in its operations as the law of gravitation. In the Quart. Journ. of the Geol. Soc. vol. xlviii. p. 103, I defined Subterranean Erosion as follows:—

"That *wherever* water percolated through such unconsolidated beds as clays, sands, and gravels, *along an inclined plane*, it was constantly carrying the lighter materials of such strata towards the *nearest point of escape. The nearer the approach to the point of escape,*

the *greater* became the *power of subterranean erosion.* This action caused *lateral subsidence.*"

I maintain (*inter alia*) this "principle of geology" may be responsible for such widely separated events as the Submerged Peat and Forest-beds of the Estuary of the Thames, the swamps of America, the Contorted Drifts of Norfolk, and the "thick coals" of South Staffordshire. WILLIAM SHONE.

UPTON PARK, CHESTER, *Dec.* 18, 1892.

OBITUARY.

PROFESSOR JOHN O. WESTWOOD, M.A., F.L.S., &c.

HON. PRESIDENT ENTOMOLOGICAL SOCIETY OF LONDON;
HOPE PROFESSOR OF ZOOLOGY IN THE UNIVERSITY OF OXFORD.

BORN 1805. DIED 2 JANUARY, 1893.

ANOTHER venerable Professor has passed away in the opening of the New Year. John Obadiah Westwood was the son of the late Mr. Westwood, of Sheffield, and was born in that town in the year 1805. Having been privately educated at Lichfield, he shortly after commenced active life and migrated to London, where he early displayed an ardent love of Entomology. He was one of the original members of the Entomological Society of London, founded in 1834, and after being twice President, was elected honorary life President. His "Introduction to the Modern Classification of Insects" and the "Entomologist's Text-Book" appeared in 1838; his "British Butterflies and their Transformations," in 1841; "Arcana Entomologica"; "British Moths and their Transformations," &c. in 1845; "Cabinet of Oriental Entomology," in 1848; Descriptions of Fossil Insects in the Rev. P. B. Brodie's "History of the Fossil Insects in the Secondary Rocks of England" (London 1845 with 11 plates), and a valuable paper on Purbeck Insects (Quart. Journ. Geol. Soc., Vol. ix. pp. 378–396, 1854).

In 1855 the Royal Society presented him with one of the Royal Medals in recognition of his valuable contributions to Entomology.

In 1861 Mr. Westwood was appointed to the professorship of Zoology in the University of Oxford, then newly founded by the munificence of the late Rev. F. W. Hope. Soon afterwards the Professor was made an Honorary Fellow of Magdalen College, Oxford. Professor Westwood was joint author with Mr. C. Spence-Bate, of a "History of the British Sessile-eyed Crustacea" (2 vols., 1863–1868). He was a Fellow of the Linnæan Society for nearly 70 years, and was an Honorary or Corresponding Member of the Entomological and Zoological Societies of Paris, Holland, Belgium, Berlin, Stettin, Munich, Vienna, Stockholm, St. Petersburg, Moscow, Quebec, Boston (U.S.A.), and many other Societies. His separate papers are too numerous to quote here. As a draughtsman of Insects he was highly skilled. He continued his lectures at Oxford till a very recent date, and his loss is deeply regretted in the University.